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**Studies**  
on the  
**Ectoparasitic Trematodes of Japan,**

by

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*With Plates I-XXVII.*

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**Introduction.**

It was originally intended that I should publish these studies jointly with Prof. Ijima; but as he is engaged on another work, it has become necessary for me to take the whole responsibility upon myself. The species on which these studies were made were for the most part collected by myself from various parts<sup>1)</sup> of Japan during the summers of 1889, '90, '91, and '92. The present part does not include the *Gyrodactylidae*, the study of which I am still prosecuting; and as this will occupy me for some years longer, I have thought it advisable to publish what is ready now, particularly as I have already been able to make out the general anatomy of some of the *Gyrodactylidae*, and can therefore take them into account in judging of the natural affinities of the different species.

The specimens collected by me were usually killed with hot saturated solution of corrosive sublimate. This reagent gives, so far as my experience goes, the best general result, fixing the worms usually in an outstretched condition and thus facilitating the process of sec-

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1). The collection was made at the following localities: Hakodaté, Misaki, Tōkyō, Mitsugahama (in Iyo), Ujima (the port of Hiroshima), Hagi, and Mogi (near Nagasaki).



tioning. Moreover, corrosive sublimate can be so easily carried about, and its saturated solution so easily made that it is, generally speaking, by far the best reagent for use on a collecting tour. The specimens were preserved in 70 % alcohol.

For staining sections I have almost exclusively used Kleinenberg's solution of haematoxylin. I have tried picro-carmin and borax-carmin, but they did not give good results, although the latter was very excellent for staining specimens mounted *in toto*. I have also tried cochineal tincture so highly recommended by Lang for the glandular cells of polychaets; but it gave no differential staining whatever.

For preparation *in toto*, the specimens were killed under the pressure of a cover-slip over the flame of an alcohol lamp, and were directly immersed in 70 % alcohol, in which they were preserved together with other specimens. For staining I have used borax-carmin; the over-stain being thoroughly washed out with acidulated 70 % alcohol. In most specimens, only the internal organs and the nuclei of the mesenchyma remain stained, while the mesenchyma itself is wholly decolourised, so that the result forms altogether a very beautiful object under the microscope.

To Prof. Ijima and Prof. Mitsukuri are due my warmest thanks both for supervision and for giving me suggestions and the most friendly assistance. To Profs. Parona and Perugia of Genoa, Prof. Monticelli of Naples, and Prof. Ramsay Wright of Toronto, I am indebted for their courtesy in sending me their papers on ectoparasitic Trematodes. Finally but not least my best thanks are due to the authorities of the Imperial University for taking charge of the publication of the paper.

## A. Anatomy and Histology.

### 1. *External Form of the Body.*

Broadly speaking, the form of the body is that of the blade of a leaf with a rounded apex ; and as the leaf varies from an orbicular to a linear or lanceolate shape, so the body of ectoparasitic Trematodes varies in form between the same extremes. In *Microcotyle* the body is generally elongated and lanceolate or fusiform, the posterior end being rather pointed. In some species of this genus the halves of the body are asymmetrical, one being longer than the other, so that the axis of the body forms a curve or even a crooked line ; *e.g.* in *M. reticulata* (Pl. I, fig. 5) and *M. sciænae* (Pl. II, fig. 6).

In cross-sections the body of *Microcotyle* presents the form of an ellipse, of which the minor axis becomes greater and the major axis much shorter as the section approaches the anterior end. In the posterior portion of the body where the suckers are present, the cross-section is often semicircular in outline, the diameter being the ventral side.

In *Acine* (Pl. VII), one side of the body is always longer than the other, and the posterior portion of the longer side makes an angle with the anterior part, so that this portion looks like the posterior margin of the body, and has actually been so regarded by preceding writers. But that it is really a part of the lateral margin of the body seems to me beyond doubt both from the presence of suckers on the other side and from the course of the principal nerves and the excretory vessels to be described further on. In *A. aberrans* the sucker-bearing portion of the longer side is perfectly straight and makes an acute angle with the anterior part, so that one is tempted to regard it as the posterior border of the body ; but here too there is a sucker on the other side. In accordance with the general asymmetry

of the body, the posterior end has come to be situated quite laterally, and the general form of the body to be more or less triangular.

An interesting fact relating to the asymmetry of the body in *Aeine* is that the longer side may be either the left or the right. Thus, in *A. heterocerca*, out of the nine specimens which I have examined for the purpose, three had the left side of the body shorter while in the remaining six the right side was shorter. This fact, though apparently insignificant, will be found to be of use at least as a check in judging of the value of some diagnostic characters given by previous workers.

The cross-section of the body is in *Aeine* band-shaped; and the thickness of the body diminishes, while its breadth increases, as we proceed towards the posterior part, so that in this region the cross-section presents the shape of a narrow ribbon.

In *Diclidophora* (Pl. X), the cross-section presents no great deviation in outline from that of *Microcotyle*, but the general form of the body is greatly modified by the fact that the four pairs of suckers are hemispherical, and are borne on the posterior margin of the body arranged in a semicircle or in a horse-shoe shape. Moreover, in many species each sucker is borne on a long pedicel (Pl. X, fig. 9), a feature evidently which has suggested the generic name of *Octodactylus* to Sir John Dalyell. The portion which bears the suckers, the "Haftscheibe" of German authors and which I shall call the "caudal disc," is in all species more or less distinctly separated from the anterior portion by a constriction of the body. In *Diclid. tetradonis* (Pl. X, figs. 1 & 2), however, the posterior portion of the body is considerably elongated, so that the transition to the caudal disc is more gradual.

In *Hexacotyle* (Pl. XIII), the body is again much flattened, but its absolute thickness is very much greater than in the other genera.

It is sharply pointed at the anterior end, very broad in the middle portion, presents a constriction at a short distance from the posterior end, again broadens out, and then suddenly diminishes in breadth, so that at this part the lateral borders form the two equal sides of a very flat isosceles triangle with its apex directed posteriad, and have generally been designated as the posterior border. There is however a small notch at the apex.

In *Octocotyle* (Pl. IX) and *Onchocotyle* (Pl. XV), the body is comparatively much thicker, and the cross-section presents in some parts almost a circle. In *Octocotyle*, the caudal disc is not distinctly distinguishable from the rest of the body, the suckers being borne simply on the ventro-lateral margins of the posterior portion (Pl. IX, fig. 7). In fig. 1 on Pl. IX, the caudal disc is apparently set off from the remaining portion of the body by a sudden diminution of breadth; but this has been caused by the specimen having been killed under the pressure of a cover-slip, and the body proper having been abnormally flattened in consequence. In fresh specimens or in those killed free, there is no such distinct boundary. In *Onchocotyle*, on the other hand, the caudal disc is distinctly marked off from the anterior part by a constriction, and bears, as is well known, a subcylindrical appendage projecting from its anterior end on the dorsal side of the body. The end of this appendage, which bears a pair of suckers (mistaken by Taschenberg for the terminal vesicles of the excretory system, see p. 28) and a pair of hooks, is in my opinion to be regarded as the posterior end of the body, with the body bent a little obliquely on itself towards the dorsal side, so that the suckers have come to lie apparently on the dorsal side. In proof of this view, it may be mentioned (1) that the two surfaces of the appendage and the caudal disc are seen, in serial sections, to be directly continuous with the dorsal and ventral surfaces of the body; (2) that there is a pair of hooks at the end of

the appendage, which is usually the case in other genera; and (3) that according to this view the apparently dorsal side on which the suckers are borne, is really the ventral side, a fact in harmony with all the cases hitherto known.

In *Monocotyle* (Pl. XVII) again, the body is much flattened, and its cross-section presents almost the form of a crescent whose inner side is ventral. In general outline the body is elongated, broad, and a little bordering on the oval. The posterior end is quite sharply pointed. Anteriorly the body becomes narrower, but again somewhat broadens out in front, where at the end there is a large, shallow notch (Pl. XVII, figs. 1 & 2). In *Calicotyle* (Pl. XIX), the shape of the body is that of an ovate, heart-shaped leaf, its apex forming the anterior end, and its basal notch bearing the posterior sucker (Pl. XIX, figs. 1, 2, & 3).

In *Tristomum* (Pls. XX—XXV), the body is mostly notched at the posterior end, and its form varies from that of an orbicular to that of an oval or ovate, heart-shaped leaf with apex more or less truncate; the truncated border being sometimes convex, sometimes concave, and sometimes almost straight. In *Epibulella*, the body presents the same general outline as in *Tristomum*, except that the posterior end, instead of being notched, becomes gradually narrower and is directly continued into the sucker.

## 2. The Investing Membrane.

In my paper on *Diplozoon*<sup>1)</sup> I called this membrane the epidermis, assuming in so doing that it corresponds to the true epidermis of other animals. I have still no cause for recantation; but as an antagonistic

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1). This Journal, vol. IV, pt. 1, 1890

opinion has been advanced by Brandes,<sup>1)</sup> and as the genesis of the membrane in question has not been made out embryologically, I have thought it better to use a non-committal term, and have adopted for this purpose the name used by Wright and Macallum,<sup>2)</sup> although it is in some respects not a very convenient one.

Three layers can be distinguished in the investing membrane of the ectoparasitic Trematodes. These I shall call the *cuticle*, the *sub-cuticle*, and the *basement membrane*. These terms, I am well aware, are all preoccupied, and bear different significations according to different writers; but the coinage of new words is not very desirable and is moreover not an easy task for one writing in a foreign language. Words hitherto in use can, however, be used in a new sense without any danger of occasioning confusion, when clear definitions are given. The term "subcuticle" might be somewhat objectionable, as liable to be confounded with the "Subcuticularschicht" of Taschenberg and some other writers on Trematodes; but this is now so generally recognised to be nothing more than the cortical portion of the mesenchyma that there is, I believe, no serious danger of introducing confusion of ideas by adopting, in this paper at least, the terminology here proposed,<sup>3)</sup> in place of 'epidermal layer' which I used in my former paper.

The *cuticle* is a very thin, structureless, refractive layer which is very distinct in fresh specimens. In sections its existence is indicated

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1). Brandes—Zum feineren Bau der Trematoden. Zeitschr. f. wiss. Zool., Bd. 53, 1892, p. 558.

2). Wright and Macallum—Sphyrnura Osleri. Journal of Morphology, vol. I, 1887, p. 1.

3). Monticelli in a paper which was received after the above had been written, calls the investing membrane "ectoderma," and claims to have demonstrated in it the remnants of the original nuclei in the form of vesicles containing deeply stained corpuscles. Granting that the nuclei of the original epidermis may in some species remain in a comparatively unaltered state, it seems to me that the vesicles figured by Monticelli are too numerous to be regarded as the remnants of the nuclei of the ectoderm of the *Cercaria*, which are, according to the statements

by a fine line on the external surface of the investing membrane, which usually stains in haematoxylin deeper than the subjacent layer; but its thickness is always very insignificant, and can not be measured with any approximation to accuracy even under the magnifying power of 300 diameters. But that it is a distinct layer of cuticular nature is clearly proved by the fact mentioned in my former paper, that when any fresh specimen is observed in water under the cover-glass for a sufficient length of time, watery blisters are formed in various parts of the investing membrane, and the cuticle is raised from the subjacent layer.

Next to the cuticle comes a layer of varying thickness, forming my *subcuticle*. In its behaviour towards staining fluids, it is somewhat different in different species, the difference, however, lying only in the different intensity of its affinity with stains. For instance, in *Microcotyle* and *Onchocotyle* it is but slightly stained, while in *Tristomum* and *Monocotyle* it takes up the stain with greater avidity. In most species this layer is more or less granular, the ground-substance being formed by a uniformly stained, structureless substance. This ground substance seems, in the fresh state, to be of a semifluid nature in most cases, and of a greater density than water. This I infer from the fact that when watery blisters are formed under the circumstances already referred to, the water seems to pass into the subcuticle by a simple osmotic process and mix freely with its substance,—the substance of the subcuticle being quite undistinguishable from the water taken in. In *Onchocotyle*, the subcuticle appears striated in cross-section, the striation being caused by numerous fibrillar structures traversing it at right angles to its thickness. Besides these fibrils,

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of Schwarze, Schauinsland, and Biehlinger, very few in number (*Cf.* Monticelli—*Studi sui Trematodi endoparassiti: Primo contributo di osservazioni sui Distomidi.* Spengel's *Zoolog. Jahrbücher*, III. Supple., 1893.).



granules are also observable. In all the other species, the subcuticle shows only granules, which are, however, more numerous in some than in other species. For instance, in *Microcotyle*, *Aciue*, *Monocotyle*, *Dictidophora*, and *Hexacotyle* the granules are comparatively sparse, while in *Tristomum* they are very numerous and exceedingly fine in certain regions, *e.g.* on the ventral side of the anterior suckers.

Inward to the subcuticle comes the *basement membrane*. In cross-sections it is very deeply stained, and very distinctly separable from the subcuticle but somewhat less so from the subjacent mesenchyma. Its thickness can not be measured with any accuracy, but it is always thicker than the cuticle. Hallez<sup>1)</sup> has shown with regard to planarians, that the basement membrane is of the same nature as the dense layer of connective tissue that surrounds the internal organs. Genetically therefore it belongs to the mesenchyma rather than to the investing membrane, and it is only in accordance with custom that I have described it as forming one of its layers.

In *Tristomum sinuatum* and *Trist. orale* there are numerous papillae on the surface of the body. These are of two kinds. Those of one kind are mostly perceivable with the naked eye. In *Trist. sinuatum* they are confined to the dorsal surface of the body, and measure on the average about 0.028 mm. in height, the extremes being 0.014 mm. and 0.041 mm.; the larger ones appearing to the naked eye as granulations. In *Trist. orale*, on the other hand, they are confined to the ventral side where they are very numerous, and are much larger than in *Trist. sinuatum*, measuring on the average about 0.08 mm. in height, the extremes being 0.032 mm. and 0.122 mm. The papillae of the other kind are all microscopic and are far less numerous than those of the first kind. In *Trist. orale* they are

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1). Hallez—Embryogénie des Dendrocoèles d'eau douce, 1887. p. 78.

almost uniformly distributed on the dorsal surface, while in *Trist. sinuatum* they are mostly confined to near the lateral margins of the ventral side; and in both species they measure on the average 0.011 mm. in height. They are probably tactile organs.

In sections the papillae of the first kind (Pl. XXIV, fig. 2) are seen to be simple elevations of the investing membrane together with the underlying mesenchyma which presents, however, a somewhat different appearance from that of the more internal parts, and will be described under the mesenchyma. These papillae are always traversed lengthwise by the terminal ramifications of the dorso-ventral muscular fibres, one of which usually ends at the very apex. The papillae of the second kind are distinguished not only by their minute size but also by the total absence of muscular fibrils; and although I have not been able to demonstrate in them any nervous fibril I believe it will be found out by the application of appropriate methods.

The total thickness of the investing membrane is in *Microcotyle* usually a little less than 0.005 mm.; in *Axine heterocerca* a little less than 0.004 mm.; in *Dididophora* 0.005 mm.; in *Hexacotyle acuta* and *Octocotyle minor* 0.004 mm.; in *Monocotyle* 0.008 mm.; and in *Onchocotyle* 0.003 mm.—0.004 mm. It should however be borne in mind that the thickness of the investing membrane varies considerably in different parts of the body. Thus, in *Tr. orale* it is 0.003 mm. on the ventral side and 0.012 mm. in the anterior part of the dorsal side; again in *Tr. sinuatum* the thickness varies from 0.003 mm. on the dorsal side of the posterior sucker to 0.01 mm. on the dorsal side near the anterior sucker. It is also to be noted that the thickness is sometimes less on the dorsal than on the ventral side, *e.g.* in *Onchocotyle*.

Having described the investing membrane as it is according to my own observations, I may now refer to some views relating to its

nature. These views may be divided into two classes, *viz.*, that which regards the investing membrane as a true cuticle, and that which regards it as the transformed product of the originally cellular epidermis. Among the most recent writers on ectoparasitic Trematodes, Brandes represents the first view and Braun the second.<sup>1)</sup> According to the former writer<sup>2)</sup> the investing membrane is to be regarded as a true cuticle and as the secretion product of numerous unicellular glands scattered in groups in the cortical portion of the mesenchyma (Ectoparenchym), the presence of which he claims to have demonstrated in all the forms studied by him for the purpose. In opposition to this view, Braun<sup>3)</sup> brings forward the fact that in *Monostomum mutabile* there are disseminated in the investing membrane ("Hautschicht") numerous oval nuclei with sharp outline and staining weakly with picro-carmin. In absence of any direct embryological proof it is of course useless to dogmatise on either side. But, even laying aside the fact observed by Schwarze<sup>4)</sup> that the investing membrane of *Cercaria* is a transformed epidermis as not quite conclusive with respect to that of the adult worm, the positive facts<sup>5)</sup> at present known, when taken together seem to me to be strongly in favour of the view upheld by Braun. For instance, the observation of Zeller<sup>6)</sup> on *Polystomum*, that in it the epidermal cells are not cast off but have their nuclei merely shrivelled up, strongly points to

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1). As stated in a previous note Monticelli is of the same opinion.

2). Brandes—*l. c.*

3). Braun—Ueber einige wenig bekannte resp. neue Trematoden. Verhandl. d. deutsch. zool. Gesellsch., 1892. p. 51.

4). Schwarze—Die postembryon. Entwickl. d. Trematoden. Zeitsch. f. wiss. Zoolog., Bd. 42, 1886. p. 49.

5). It is perhaps hardly necessary to remark here that the "matrix cells" of Wierzejski are in reality the nuclei of the mesenchyma. Cf. Wierzejski in Zeitsch. f. wiss. Zoolog., Bd. 29, 1877. p. 552.

6). Zeller—Weiterer Beitrag z. Kenntniss d. Polystomen. Zeitsch. f. wiss. Zoolog., Bd. 27 1876. p. 262.

the continued existence of the original epidermis. Besides, the differentiation of the investing membrane into the true cuticle and the subcuticle, and the negative fact that, although I have directed my special attention to the point, I have utterly failed to observe those subcuticular glands so beautifully drawn by Brandes in his figures in the very same genera that he describes, strongly incline me to the view that the investing membrane of the ectoparasitic Trematodes is a transformed epidermis. I have indeed observed some cells in the ectoparenchyma which had the appearance of a gland (Pl. XXI, fig. 4), but I have not been able to find out any duct, and believe them to be cells of the mesenchyma and will therefore describe them under that head. From his statements on p. 565 (*op. cit.*), I gather that Brandes regards the muscular fibres described by Poirier<sup>1)</sup> in some species of *Distomum* as the ducts of the subcuticular glands; but Poirier's figure in question is so clearly drawn that I doubt whether one is justified to put another interpretation on it unless he has studied the very same species. In Brandes' figures the muscular fibres and the ducts of the subcuticular glands are distinguished by different colours, but according to my own experience it is very doubtful whether such difference in colour reaction exists really in nature. Moreover the ducts of the subcuticular glands are drawn so fine in Brandes' figures that one would be tempted to regard them also as muscular fibres if they were coloured alike; and for my own part I do so regard them. In this connection it may be mentioned that on examining once a series of sections of *Hexacotyle grossa* which were somewhat overstained, the terminal portions of the dorso-ventral muscular fibres were so deeply stained that they looked just like the efferent ducts of some

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1). Poirier—Contribution à l'histoire naturelle des Trématodes. Archives de Zool. expér., 2. série., T. III, 1885.

glands ; but on comparing it with another series of sections I was able to demonstrate clearly their muscular nature.<sup>1)</sup>

### 3. *Musculature.*

The musculature of the body of the Trematodes consists, as is well known, typically of four sets of fibres. *viz.*, the *circular*, the *diagonal*, the *longitudinal*, and the *dorso-central*. There are, however, some variations in different species and genera ; and I shall proceed to note them in the species studied by me.

In *Microcotyle*, *Axine*, *Onchocotyle*, *Octocotyle*, *Monocotyle*, *Calicotyle*, and *Tristomum* I find the musculature of the body to consist of the typical four sets of fibres ; but the different sets or layers are developed in different degrees in different species. Thus in *Microcotyle*, *Axine*, *Octocotyle*, *Dictidophora*, *Monocotyle*, and *Calicotyle*, the circular fibres are very fine and are directly applied to the basement membrane, so that they appear in sagittal sections of the worms as minute dots arranged at regular short intervals. In cross-sections of the worms they are very difficult to demonstrate. In *Tristomum*, on the contrary, the individual circular fibres are stronger and they are generally at some distance from the basement membrane (Pl. XXI. fig. 4 ; Pl. XXIII, figs. 4 and 7 ; Pl. XXIV, fig. 2), leaving a layer of mesenchyma of variable thickness between. In *Onchocotyle* and *Hexacotyle* the circular fibres seem to be entirely wanting.

In *Dictidophora* an additional layer of longitudinal fibres comes between the circular and the diagonal fibres (Pl. X. fig. 4 & Pl. XI, figs. 3 & 5). The individual fibres of this layer are separated from one another by an intervening mass of mesenchyma ; they are usually oval or circular in cross-section and are generally a little finer than those of the inner longitudinal layer. This layer has also been

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1). Compare on this question the more exhaustive discussions in Monticelli's paper (*Primo contributo etc.*, p. 202 *et infra*).

observed in some turbellarians. I have been able to demonstrate it in all the three species of *Diclidophora* which I have studied. The fibres are usually arranged in a single layer; but on the ventral side of *Diclid. tetrodonis* they are, irregularly, more than one layer thick (Pl. X, fig. 4). In the pedicels of the posterior suckers of the genus under consideration, only the circular fibres are present (Pl. XII, fig. 4); the longitudinal fibres forming in each an axial bundle which is attached to each sucker.

The diagonal fibres that come next the circular, or in *Diclidophora* next the outer layer of longitudinal fibres, are most strongly developed in *Tristomum*. In *Trist. orale* (Pl. XXIII, fig. 7 & Pl. XXIV, fig. 2) this layer consists of numerous fibres which are rather closely crowded and cross each other at variable angles according to the different states of contraction of the body. The individual fibres are somewhat weaker than the circular fibres. In *Trist. sinuatum*, on the other hand, the absolute number of fibres that constitute this layer is considerably less than in *Tr. orale*, but the individual fibres are much stronger (Pl. XXI, fig. 4), and cross each other at an acuter angle. The last mentioned fact can not only be demonstrated by an examination of preparations *in toto* but is also evident from the fact that in sections of equal thickness of the two species a shorter portion of each fibre is cut in the one than in the other (*cf.* Pl. XXI, fig. 4 & Pl. XXIII, fig. 7).

In *Diclidophora* the individual fibres of this layer are very much finer than the longitudinal fibres, but are comparatively numerous (Pl. XI, figs. 3 & 6; Pl. X, fig. 4). In *Hexacotyle*, on the other hand, the fibres are not so numerous, but each one is only a little inferior in size to the longitudinal fibre. In *Acline* (Pl. VIII, fig. 1) and *Mono-cotyle* (Pl. XVIII, figs. 2 & 5) the fibres are very fine and not very numerous. Finally in *Microcotyle* the diagonal fibres are very weakly developed and can be demonstrated only in preparations *in toto*.

As may be seen from the figures referred to, the layer of diagonal fibres is generally separated both from the circular and the longitudinal fibres by a thin intervening layer of mesenchyma.

The layer of inner longitudinal fibres is the most strongly developed of all the muscular layers of the body, both as a whole and in the strength of the individual fibres that constitute it. In *Axine* and in most species of *Microcotyle*, the fibres of this layer are not arranged in bundles but are almost uniformly scattered in a distinct layer of the mesenchyma (Pl. IV, figs. 6, 7, & 8; Pl. VIII, fig. 1), and present oval or circular outlines in cross-sections. In *Tristomum* (Pl. XXIII, fig. 7 & Pl. XXIV, fig. 2), *Oncocotyle* (Pl. XV, fig. 10 & Pl. XVI, fig. 8), and *Hexacotyle* (Pl. XII, fig. 5) the fibres are united only into loose bundles; but in nearly all the other species studied by me, the fibres of this layer are associated in compact bundles, and present in cross-sections generally polygonal outlines, evidently due to mutual pressure. In some species, as in *Hexacotyle acuta* and *Microcotyle reticulata*, this inner layer of longitudinal fibres is again divisible into two layers. In the former species the outer of the two layers is constituted by a single layer of strong fibres at various distances from each other (Pl. XII, fig. 5). The longitudinal fibres of *Microcotyle reticulata* present some variations of arrangement, which will be briefly noted.

In the more anterior part of the body (Pl. V, fig. 6) the fibres are in this species distributed apparently without order, but the outer fibres are considerably smaller than the deeper ones. In the region of the vagina the fibres of the two layers are almost equal in size (Pl. V, fig. 5); but in most portions of the body the longitudinal fibres are arranged in compact bundles, the outer fibres of which are considerably smaller than the inner (Pl. III, fig. 4). In this species the circular and diagonal fibres are but weakly developed and can not



be demonstrated in cross-sections : so that the layer of longitudinal fibres seem in such sections to be separated from the investing membrane only by a layer of mesenchyma (Pl. III. fig. 4).

The dorso-ventral muscular fibres are developed in very different degrees in different species, but they are, so far as I have observed, never wanting. They are but weakly developed in *Axine* and in most species of *Microcotyle* ; moderately in *Dididophora*, *Hexacotyle*, *Onchocotyle* and *Monocotyle* ; and very strongly in *Tristomum*. It is, as is well known, the characteristic of the dorso-ventral fibres that they ramify into a number of fine branches towards their ends, and are inserted onto the investing membrane of the body. They also traverse some internal organs, such as the testes and the vitellarium.

In *Monocotyle* there are in the hindmost portion of the body an assemblage of striped muscular fibres (Pl. XVII. fig. 5) ; but as these are present mainly in the posterior sucker, they will be described in that connection.

#### 4. *The Organs of Attachment.*

Under this head I include the suckers, both true and rudimentary, the glands, which subserve, according to my opinion, the same purpose, and the hooks. These, but especially the glands, are more numerous and of more varied structure than has hitherto been thought.

SUCKERS—The suckers may be classed, for the sake of description, into the anterior and the posterior suckers, of which the latter present more variety of structure than the former. The differences in both of them are characteristic of the genera, and so will be treated separately under each genus, except where another treatment is more desirable.

*Microcotyle* and *Axine*—In these two genera the anterior and posterior suckers are of the same structure. They will therefore be treated of together and minor differences occasionally noted.

The *anterior suckers* consist in both the genera of a pair of bag-shaped bodies with thick walls, and situated one on each side of the mouth-cavity (Pls. I, II, III, & VIII). The shape of the sucker is very variable according to the different states of contraction of the part of the body it belongs to, and also differs somewhat in different species; but when in a state of rest it is generally circular, ellipsoidal, or egg-shaped (Pl. III, fig. 8; Pl. VII, fig. 1). Its cavity is directly continuous with that of the mouth, and in most species of *Microcotyle* it is divided into two compartments by a structureless, membranous septum that usually runs obliquely to the long axis of the body; but the septum is also absent in some species, as in *M. reticulata*. Parona and Perugia<sup>1)</sup> mention “piccolissimi e splendenti corpicciuoli rotondi disposti a gruppi, od in una fascia” on the free margins of the suckers; but I have not observed such structures. The wall of the sucker consists of very refractive, prismatic fibres of a yellowish colour traversing its whole thickness, which remain entirely unstained in haematoxylin, picro- or borax-carmin. These fibres are closely appressed to one another—the prismatic shape being apparently due to mutual pressure—and only a very thin layer of connective tissue is left between them. This layer of connective tissue stains more or less, and in consequence, the substance of the wall of the sucker appears in sections striated at right angles to its surfaces. These fibres are different in appearance as well as in colour-reaction from the muscular fibres of the body, and are perfectly like those of the posterior suckers and of the mass of connective tissue around the terminal portion of the vas deferens in the genera

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1). Parona e Perugia—Res. ligustice, XIV. Contribuzione per una monografia del genere *Microcotyle*, p. 4. Estratto dagli Annali del Museo Civico di Storia Naturale di Genova. Ser. 2, vol. X, 1890.

under consideration. In fact I consider them to be more of an elastic than a contractile nature ; but the reasons for so regarding them will be stated at length further on under the head of general considerations (*vide infra*, p. 144).

The surface of the wall of the anterior sucker is covered on all sides by a thin cuticle (Pl. III, fig. 8). On the side turned towards the mesenchyma, the fibrous connective tissue of the body forms, next to the cuticle, a thin dense layer similar in appearance to the basement membrane already described.

Each anterior sucker is provided with two muscular bundles, one of which, the larger, is attached to its postero-lateral part and the other, the smaller, to the postero-median part (Pl. III, fig. 8). Posteriorly these muscular fibres become mingled with the longitudinal fibres of the body.

The physiology of suction will be considered later on (*vide* p. 147).

*Posterior suckers*.—These are usually very numerous in both *Axine* and *Microcotyle*, and in most species of the latter are symmetrically arranged on both sides of the caudal disc, while in the former genus they are always asymmetrically arranged on the two sides in accordance with the general asymmetrical form of the body already described. Their sizes differ in both the genera in different parts of the caudal disc ; the general rule being that they are largest at the middle of the disc and diminish in size towards the ends. The posterior suckers are however mostly smaller than the anterior ones.

In *M. reticulata* and *M. sciuenae* the suckers are more numerous on the right than on the left side ; and in the latter species the caudal disc is bent at an angle towards one side, while in the former the right side presents only a greater curvature. This asymmetry of the body is, as already stated, due to the fact that its one side is longer

than the other. In *M. seiuenae* the suckers of the two sides do not present any considerable difference in size<sup>1)</sup>; but in *M. reticulata* those of the left side are much larger and fewer in number than those of the other. Thus, in the latter species a measurement of the breadths of the corresponding suckers of the two sides at about the middle of the caudal disc gave for the left side 0.227 mm. and for the right 0.145 mm.

In the specimens of the two species figured on the plates the right side is longer and bears more suckers<sup>2)</sup> than the left; but whether this is constantly the case or not I have not had a sufficient number of specimens to decide (*cf. infra de Axine*).

In *M. caudata*, *M. sebastis*, *M. elegans*, and *M. fusiformis* the caudal disc extends for some distance anteriorly from the point where it becomes continuous with the body proper; but in all the other species it does not, and the suckers are arranged merely along the lateral margins of the body.

In *Axine* the asymmetry which we have observed in the two species of *Microcotyle* above mentioned is carried one step farther, and one of the sides of the caudal disc makes an angle with the corresponding side of the body proper (Pl. VII), and appears like the posterior border (the "appendice ptéroïde" of v. Beneden). The other side bears only a small number of suckers. In some species, as in *A. triangularis* (Pl. VII, fig. 7), the suckers of the two sides are nearly of the same size; but in *A. heterocerca* (Pl. VII, fig. 1) they are of very different sizes on the two sides. Thus in one specimen, one of the largest suckers on the longer side was 0.60 mm. in breadth,

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1). For minuter details see description of species.

2). Parona and Perugia (Res. ligusticæ, XIV, p. 38) believe that a similar asymmetry occurs in *M. erythrini*; but in my opinion, the supposed asymmetry in this case is only apparent, having been caused by pressure and the twisting of the body at the point of attachment of the caudal disc, as occurs very often when the worm is observed under the cover-slip. The real asymmetry could only be caused by the unequal length of the sucker-bearing portion of the two sides, and there is none in the species in question.

while that of the other was only 0.095 mm. On the longer side the largest suckers are, as in *Microcotyle*, generally found in the middle portion; but on the shorter side the suckers gradually diminish in size from before backwards. In *A. aberrans*, however, the suckers are all of nearly equal size on the longer side. Lorenz<sup>1)</sup> and others mention the suckers only on the longer side; but in all the species studied by me they are present on both sides (Pl. VII, figs. 1, 5, & 7).

Now as to structure, each posterior sucker may be likened to a flattened, rectangular bag open on the ventral side, the broader sides of which face forwards and backwards and have a very thick wall, while on the narrower sides the wall is very thin. This bag is supported by a chitinous<sup>2)</sup> frame consisting of five pieces, *viz.*, four lateral pieces in pairs and one median. Of the four lateral pieces two are imbedded in the substance of the anterior wall and two in that of the posterior wall, both along the lateral margins (Pl. II, fig. 7). These are curved like a hook, are somewhat triangular in cross-section, and are entirely solid. The rods of the anterior wall (*a*) are, at the bottom of the sucker, directly continued on into the posterior wall (*a'*)<sup>3)</sup>; and the whole has, therefore, somewhat the form of a hook (*cf.* Pl. III, fig. 1 & Pl. II, fig. 7). Those of the posterior wall (*b*) end bluntly at the

1). Lorenz—Ueber die Organisation der Gattungen Axine und Microcotyle. Wiener Arbeiten von Claus. Bd. I, Hft. 3, 1878, p. 4.

2). I have used the word "chitinous" here and shall use it in describing the hooks in accordance with the usual custom; but it should be noted that these pieces are sometimes well stained with haematoxylin—exactly under what circumstances I have not been able to make out; but one condition seems to be that the specimen be preserved after a certain disintegration of the tissues has set in—and that the hooks are soluble in a solution (35 %) of caustic potash.

3). I take this opportunity to correct my statement on this head with regard to *Diplozoon nipponicum*. In my paper on this worm (*i.e.*) I have described the piece imbedded in the posterior wall and projecting towards the median piece as the process of the paired (lateral) piece of the posterior wall, whereas it is in reality the direct continuation of the paired piece of the anterior wall, just as in *Microcotyle*.

bottom of the suckers. The median piece (*c*) is also imbedded in the substance of the wall, and has the form of a regular U, one arm of which lies in the anterior and the other in the posterior wall. The two ends are however somewhat different in form (Pl. III, fig. 1). In the anterior wall the median piece ends with two spine-like processes diverging from each other and almost meeting the ends of the lateral pieces. In the posterior wall, on the contrary, these processes are very much shorter and blunter, and the piece bears between them a dagger-shaped, hollow, terminal piece (Pl. III, fig. 1). In cross-section, the median piece presents for the greater part of its whole length, a rectangular outline, and is seen to be hollow. A little above the bottom of the sucker its cross-section presents the appearance drawn in fig. 7 (*c* on the upper side), Pl. II.

In *Axine* the number and relative position of the chitinous pieces are just the same as in *Microcotyle* (Pl. VII, fig. 2). The internal hollow of the median piece is, however, divided in *A. heterocerca* into numerous compartments by thin septa. This piece presents also a termination in the posterior wall which is somewhat different from that in *Microcotyle* and is figured in fig. 2 II, Pl. VII.

The anterior and posterior walls of the posterior sucker are very thick and are directly continuous with each other at the bottom of the sucker. Their substance consists of numerous prismatic, very refractive fibres closely appressed to one another and leaving a very thin, deeply stained layer of connective tissue between. These fibres are to all intents and purposes exactly similar to those of the anterior suckers (Pl. III, fig. 7 & Pl. VII, fig. 4). The wall is entirely surrounded on all sides by a thin cuticular membrane. In *Axine*, however, the cuticle of the internal surface is chitinized in parallel zones running parallel to the slit-like mouth of the sucker (Pl. VII, fig. 4). The lateral walls of the posterior suckers are very thin and membranous.

The muscular fibres of the posterior suckers are attached to the median chitinous piece of the posterior wall near the bottom of the suckers (Pl. II, fig. 7). They are divided into a few bundles, and are directly continuous with the longitudinal fibres of the body.

*Octocotyle, Dichidophora, and Hexacotyle*—The *anterior suckers* of these three genera present nothing specially different from those of *Axine* and *Microcotyle*, and I shall therefore pass them over, merely referring the reader to the figures (Pl. IX, fig. 8; Pl. X, fig. 6; Pl. XIII, figs. 1 & 4). I shall, however, note that in all these, there is no membranous septum, that in *Dichidophora* (Pl. X, fig. 6) some of the fibres of the internal bundle of muscle of one side cross over to the sucker of the other side, and lastly that in *Hexacotyle* the suckers are exceedingly small. The posterior suckers are, however, very different in the three genera, so that they will be treated separately.

*Posterior suckers*—In *Octocotyle* the four pairs of posterior suckers are arranged merely along the ventro-lateral border of the hindmost part of the body, so that the caudal disc is, as already mentioned, directly continuous with the body proper. Each sucker is somewhat bean-shaped, and is raised a little above the general surface of the ventral side (Pl. IX, figs. 1, 4, & 7). The anterior and posterior walls are very thick, and consist of prismatic fibres just as in *Microcotyle* and *Axine*. The chitinous framework consists of a simple basal piece (Pl. IX, figs. 3 & 10, *a*) and a pair of marginal pieces (*b*), both imbedded in the substance of the wall. The basal piece is nearly straight and bears at each end a short process which makes a right angle with it, and is directed towards the mouth of the sucker. The marginal pieces are U-shaped and are imbedded in the substance of the anterior and posterior walls along their very margins, so that each



piece, together with the basal piece, encloses the wall like a picture in its frame. The muscular fibres are attached to the basal piece, and are direct continuations of the longitudinal fibres of the body. In *O. major* the marginal chitinous piece is longer than in *O. minor*.

In *Diclidophora* (Pl. X) the four pairs of suckers are, as already stated, borne, in most species, each at the top of a pedicel; but in *Diclid. sessilis* the stalk is very short, and in *Diclid. tetradonis* entirely wanting. But that these species are to be included in the same genus will, I believe, be scarcely contested by any one who has studied their anatomy. The suckers are in a surface view usually circular, as in *Diclid. sessilis* and *Diclid. elongata*, but are sometimes slightly elliptical as in *Diclid. tetradonis*, and are arranged in a semicircle or horse-shoe shape. Each sucker is as a whole nearly hemispherical, and its open end is directed obliquely towards the ventral side. The wall consists of prismatic fibres, and is divided into four equal parts by as many chitinous rods radiating from the centre of the sucker (Pl. XII, fig. 4). The whole number of the chitinous pieces is eight for each sucker, and are represented in their natural positions as seen from the surface in fig. 1, Pl. XII. A T-shaped piece (*a*) is situated with the point of junction of the leg and arms exactly in the centre, with the two arms of unequal length extending some way towards the periphery of the sucker, and the leg extending quite to the periphery and here dividing into two branches which diverge from each other in a diametrically opposite direction. The portion of this chitinous piece corresponding to the leg of the T is hollow, but the remaining portions are all entirely solid. Another hollow piece (*b*) extends from the centre in an opposite direction from the leg of the T-shaped piece towards the periphery, which it, however, does not reach. The hook-like piece marked *c* is paired, and bears at its angle a process which is seen in sections to lie outside the substance of the fibrous wall (Pl.

XII, fig. 4, *c*). Somewhat similar but shorter pieces (*d*) lie in pairs at the peripheral end of *b*. A short spine-like piece (*e*) lies opposite the process of the piece *c* with its pointed end directed towards the piece *d*. These last-mentioned pieces, the pieces *d*, and the peripheral portions of the pieces *a* and *c* are imbedded at the very margin of the fibrous wall of the sucker (Pl. XII, fig. 4).

In the natural position of the suckers these chitinous pieces are, in most species, placed in such a way that the leg of the T-shaped piece is directed towards the median line of the body in the anterior suckers, while in the posterior suckers it is directed obliquely forward (Pl. X, fig. 5). In *Diclid. tetradonis*, however, the same piece is directed forwards in the posterior three pairs, but backwards in the foremost pair. This difference of arrangement of the pieces of the chitinous framework in the foremost pair of suckers is a curious exception to the rule.

Each of the four quadrants into which the wall of the sucker is divided, presents in radial sections an oval or semicircular mass, consisting, as in the species already described, of prismatic fibres traversing its whole thickness at right angles to its free surface (Pl. XII, fig. 4). The four quadrants are separated from each other in the centre by an intervening mass of connective tissue, in which is imbedded the central part of the T-shaped piece (*a*) already described.

The free surface of each quadrant is covered with a thick cuticle which is locally chitinated in short staff-shaped pieces arranged in series. Each series of these staff-shaped chitinous portions is, in a surface view, roughly speaking somewhat semicircular (Pl. XII, fig. 2), with the open side directed towards the centre of the sucker. In fig. 1, Pl. XII, the series have been a little displaced by pressure. Towards the mesenchyma the wall of the sucker is bounded by a thin, cuticular membrane. Around the outer margin of the sucker the

investing membrane of the body makes a fold filled with connective tissue within, and forms a marginal membrane (Pl. XII, fig. 4).

Strong bundles of muscular fibres are attached to each sucker. The principal bundles are, as may be seen in fig. 4, Pl. XII, three in number, and are attached one to the inner margin of an inner quadrant, another to its outer corner, and the third to the central part of the T-shaped chitinous piece. The individual fibres that constitute these bundles are very large. The larger part of the bundles of each sucker are merged in a single bundle at a short distance from it, and the bundle thus formed traverses the axis of the pedicel of the sucker, when such is present; but a small portion forms one or more bundles which connect the suckers with one another. I have represented this connection among the suckers as I have observed it in *Diclid. sessilis* in fig. 5, Pl. X.

In *Hexacotyle*, there are four pairs of posterior suckers, and these are arranged on each side of the median line in a line parallel with the posterior border of the body. The median pair of all is, however, very much smaller than the others, and has been entirely overlooked by some naturalists; but it has exactly the same structure as the other pairs. Each sucker is shaped like a thick but very shallow, elliptical saucer (Pl. XII, fig. 7), with its longer axis directed at a right angle to the posterior border of the body, and is provided with three chitinous pieces imbedded in the substance of its wall, which consists, as in the cases already described, of prismatic, refractive fibres closely pressed against one another. The positions of these chitinous pieces are represented in figs. 1 & 4, Pl. XIII; and in figs. 3 & 6 each piece has been separately drawn, so that any detailed description of them is, I believe, unnecessary. It is to be remarked, however, that in both the figures, *a* represents the piece at the anterior end of the sucker, *c* that at the posterior end, and *b* the central piece, and that

this last piece is imbedded in the wall of the sucker with its longer axis coinciding with the minor axis of the sucker. The substance of the wall is bounded, as in other genera, both towards the mesenchyma and the exterior by a cuticular membrane, except in the central part where the chitinous piece is imbedded, and where this is in direct contact with the mesenchyma. A strong bundle of muscular fibres, which are direct continuations of the longitudinal fibres of the body, are attached to each of the chitinous pieces of the sucker (Pl. XII, fig. 7).

*Onchocotyle*—The position and structure of the suckers are somewhat peculiar in this genus.

*Anterior sucker*—An anterior sucker is distinctly present, although some writers have denied the fact, and is situated around the mouth-cavity, and presents some resemblances of structure to that of the distomes. In cross-section, it is elliptical in outline, and is seen to occupy nearly the whole of this region of the body, merely leaving a small portion of mesenchyma in the lateral parts (Pl. XV, fig. 4). The ventral half is much smaller than the dorsal half, just as in the distomes (Pl. XV, fig. 3). The substance of the sucker consists of connective tissue interspersed with nuclei, some of which are surrounded by scanty masses of granular protoplasm, and of muscular fibres, most of which are very fine, and, radially traversing the connective tissue, are attached to the basement membrane which separates the substance of the sucker from the investing membrane of the body. Besides these radial fibres, strong muscular fibres which act as sphincters are present in the foremost part of the dorsal half of the sucker (Pl. XV, fig. 3, *sph.*)

*Posterior suckers*—These are eight in number arranged in four pairs, one of which is, however, very different both in structure and position from the others. The latter are arranged in a horse-

shoe shape seemingly on the dorsal but morphologically on the ventral side of the body, and are hemispherical in shape. The wall consists, as in the preceding cases, of prismatic, refractive fibres set closely against one another, and is bounded on all sides by a cuticular membrane. This membrane is chitinously thickened into band-shaped strips in an antero-posterior direction (Pl. XV, fig. 8). The wall of each sucker is again divided in two, each half crescent-shaped in cross-section, and separated from the other by an intervening zone of mesenchyma, in which a single, strong, hollow, chitinous piece of semicircular shape and provided with a hook at one end lies imbedded (Pl. XV, figs. 8 & 9). The inner half of the wall is smaller than the other. There is no distinct marginal membrane, but the investing membrane presents a fold all round at a short distance from the mouth of the sucker (fig. 8).

In the natural position, the hooked end of the semicircular chitinous piece is directed towards the anterior end of the body; and a strong bundle of muscular fibres is attached to the other end of the piece. Besides this, detached fibres are also attached to the lateral margin of the suckers.

The remaining pair of suckers, which are much smaller, is situated at the extremities of the bifurcations of the caudal appendage which constitutes such a salient feature of this genus. Each sucker has the shape of a water-melon with a constriction at the posterior part; and its mouth is very narrow (Pl. XV, fig. 2). Its cavity is also very narrow; but the wall is very thick, and consists entirely of a connective tissue interspersed with nuclei, which are more abundant in the posterior portion of the sucker (Pl. XV, figs. 1 and 2). The fibres of the connective tissue are mainly arranged radially, and form an irregular network. The wall is bounded towards the mesenchyma by a thin, cuticular membrane, and its inner surface is lined by the

direct continuation of the investing membrane of the body.

The pair of suckers above described has been mistaken by Taschenberg<sup>1)</sup> for the terminal vesicles of the excretory system (see p. 5).

*Calicotyle*.—*Anterior sucker*.—In this genus the anterior sucker is developed far more imperfectly than in those hitherto described, and is also totally different from them in structure. It is constituted by a deep invagination of the ventral side of the body just behind the mouth (Pl. XIX, fig. 8). From the inner surface of the investing membrane that lines the cavity of the sucker, numerous muscular fibres take their origin, and diverging in various directions, become continuous with the longitudinal fibres of the body. Besides these, circular fibres are exceptionally developed in this part. Owing to this local development of the musculature, the anterior sucker seems in a surface view to be pretty well defined from the surrounding mesenchyma, and to form a distinct organ (Pl. XIX, figs. 1 and 4); but sections show that this is by no means the case. Morphologically speaking, it would be more correct, therefore, to call it a rudimentary sucker (pseudoventose).

*Posterior sucker*.—This is situated on the ventral side at the posterior extremity of the body. Its ventral surface is marked out into a central heptagonal and seven peripheral areas by elevations of the ventral surface radiating from the wall of the central polygon. This central polygon does not occupy exactly the middle of the sucker, but is situated a little more anteriorly. The hindmost area which is the largest, occupies the median line of the body, while the others are arranged symmetrically on either side, and decrease in size from behind forwards (Pl. XIX, figs. 1 and 3).

The musculature of the sucker consists of three sets of fibres, which may be called the *radial*, the *transverse* or *dorso-ventral*,

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1). Taschenberg—Weitere Beiträge, p. 13.

and the *circular*. The *radial* fibres must again be divided into two groups. In one they are direct continuations of the longitudinal fibres of the body, and on entering the sucker diverge irregularly more or less in all directions, and are inserted, some to the elevation that forms the wall of the central polygon, others to the periphery of the sucker. The other group of radial fibres includes those fibres which start from the central polygon, and passing along the radial elevations, are inserted in the periphery of the sucker. The *transverse* or *dorso-central* fibres merely traverse the thickness of the sucker, and are inserted into the basement membrane. Like the dorso-ventral fibres of the other parts of the body, they ramify into a number of small branches towards their ends. The *circular* fibres are present only on the dorsal side; they are arranged in circles concentric with the circumference of the sucker, and are comparatively few. The interspaces between the muscular fibres are filled by a connective tissue similar to that of the body (Pl. XIX, fig. 6).

*Monocotyle*.—Morphologically speaking there is no anterior sucker in this genus, but physiologically speaking there is. The dorso-ventral as well as the circular fibres of the body, namely, are strongly developed at the anterior end around the mouth (Pl. XVIII, fig. 4), so that the arrangement of muscular fibres is very similar to that which obtains in the anterior suckers of *Onchocotyle* and of the distomes. There is even a sort of marginal membrane on the ventral lip (Pl. XVIII, fig. 4, *a*). That this anterior portion acts as a sucker is beyond doubt; for I have observed the worm execute an active leech-like locomotion by alternately attaching and detaching the mouth and the posterior sucker. In fact, the structure here described is a preliminary step to the formation of such anterior sucker as that of *Onchocotyle* and the distomes; the only difference being that in the latter, the sucker has been distinctly separated from the surrounding

mesenchyma by a compact membrane of the nature of connective tissue.

Though closely allied to *Calicotyle*, the present genus presents some peculiar feature in the structure of the posterior sucker.

*Posterior sucker*—This has exactly the shape of a circular saucer, and is attached to the body by a short stalk. It is provided with a marginal membrane all round, which is exactly of the same nature as that of the posterior suckers of *Dididophora*; only its connective tissue is more compact (Pl. XVII, figs. 2, 4, and 5). A further difference is that the membrane bears on its ventral surface numerous chitinous projections arranged in radial series; there being five of these chitinous projections in each series (figs. 2, 4, and 5). The internal surface of the sucker is divided into eight equal secants by as many radiating elevations, the positions of which are such that two of them coincide with the median line of the body. These radial elevations also bear on their surfaces each a series of chitinous pieces which are figured in radial section in fig. 3 (Pl. XVII), and in tangential section in fig. 8. In the latter figure it appears as if these pieces have been formed simply by local chitinisations of the investing membrane of the body. These so-called chitinous pieces are deeply coloured by haematoxylin, more deeply than the investing membrane.

The muscular fibres of the sucker are very different in structure from those hitherto described, and are all arranged, with an insignificant exception, dorso-ventrally (Pl. XVII, figs. 4, 5, 7, and 12). They are striped, and a single fibre traverses the whole thickness of the sucker. Each fibre (about 0.01 mm. thick) consists of very refractive, narrow zones, which deeply stain in haematoxylin, alternating with broad, non-refractive zones, which are but slightly stained with haematoxylin and are finely but distinctly striated longitudinally. Each of these non-refractive zones is again crossed at its middle by



a very narrow, secondary zone of much refractive power and well stained in haematoxylin. This zone is so narrow that it appears only as a fine line, and its refractiveness and capacity of being stained with haematoxylin are much inferior to those of the primary zone. I have observed some of these fibres bifurcating towards one of their ends (Pl. XVII, figs. 7 and 12).

The striped fibres above described are almost uniformly distributed in the secants into which the sucker is divided, as well as in the radial elevations themselves. In the latter, the fibres lie at right angles to their length, and are consequently very short (Pl. XVII, fig. 8). They may also be entirely absent from them for a more or less wide extent (Pl. XVII, fig. 3). On the other hand, they are wholly absent from those parts of the sucker which lie below the radial elevations. Here the substance of the sucker is entirely formed of connective tissue, the fibres of which unite into bundles on the ventral side in such a way as to form a series of window-like cavities (Pl. XVII, fig. 3); while on the dorsal side the fibres form generally a compact network, leaving only here and there a number of large cavities. The centre of the sucker is wholly devoid of striped fibres, and is sharply defined from the surrounding parts by a membrane of connective tissue (Pl. XVII, figs. 4 and 5). This central part is traversed by the terminal portions of some of the longitudinal fibres of the body, which are here formed into bundles and are inserted, some into the very centre of the sucker, others more peripherally into the membrane of connective tissue that separates the centre of the sucker from the surrounding parts.

As may be inferred from the above description, the sucker of *Monocotyle* is divided both externally and internally into eight equal secants—externally by radial elevations, and internally by corresponding radiating septa formed of fibrous connective tissue and wholly destitute of striped muscular fibres.

As has already been mentioned, the striped fibres are also present in the posterior part of the body (Pl. XVII, fig. 5), and this portion is, as in the sucker, sharply separated from the surrounding part by a distinct membrane of connective tissue (figs. 5 and 12).

The striped muscular fibres have hitherto been observed, so far as I know, only in the sheath of the proboscis of *Tetrarhynchus*<sup>1)</sup> among the Plathelminthes.

*Tristemonum*—As is well known, the *anterior suckers* are, in this genus, situated in a pair near the anterior extremity of the body, on both sides of the mouth or a little before it. They are more or less circular, sometimes perfectly so and sometimes a little elliptical. Internally the substance of the suckers is directly continuous with the mesenchyma of the body, and the suckers are therefore to be regarded merely as local expansions of the body. This view is strengthened by the fact that the muscular fibres of the suckers are the direct continuations of those of the body. The dorso-ventral fibres are arranged exactly as in the body, with the only difference that they are here more strongly developed in accordance with their task as the chief agent of suction (Pl. XXII, fig. 5). The longitudinal and diagonal fibres, on entering the suckers, become more or less intermingled with each other; but the former mostly radiate straight towards the periphery, while the latter curve round, and are mostly arranged more or less concentrically with the circumference of the suckers; the terminations of both the groups of fibres being attached to the investing membrane on the dorsal as well as on the ventral side. The circular fibres of the body also enter the suckers; but they here lose their typical arrangement, and become intermingled with the diagonal fibres.

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1). Pintner—Untersuchungen ü. d. Bau des Bandwurmkörpers. Wiener Arbeiten, Bd. 3, 2. Hft., 1880. p. 50.

In most species of this genus described in this paper, the investing membrane of the suckers is exactly similar to that of the other parts of the body; but in *Trist. ovale* the ventral (concave) surface is raised into numerous conical papillae, at the top of which open the efferent ducts of the numerous unicellular glands afterwards to be described. Along the inner border of the suckers also there are, in this species, numerous larger papillae crowded together (Pl. XXIII, fig. 5).

*Posterior sucker*—The posterior sucker of *Tristomum* is more or less hemispherical in form, and is very similar in structure to that of *Calicotyle*. In most species, however, a short stalk may be distinguished (Pl. XX, fig. 5). The ventral (concave) surface is divided, as in *Calicotyle*, by radiating elevations into a central and seven peripheral polygons that surround the former; the hindmost of the peripheral polygons invariably occupying the median line. In some species (*Tr. sinuatum* and *Tr. rotundum*), the central area forms a regular heptagon; but in the majority of the species studied by me, its form is that of a heptagon to one side of which an isosceles trapezoid has been apposed by the shorter one of the two parallel sides and with the boundary line between the two blotted out (*Tr. ovale*, *Tr. foliaceum*, *Tr. Nozauri*, *Tr. biparasiticum*). In *Tr. sinuatum* the two radial sides of the hindmost peripheral area bifurcate near their outer ends and there form with the margin of the sucker each a small triangle (Pl. XX, fig. 1).

A marginal membrane is always present, and is thrown into wavy folds; so that in a surface view, it seems as if it consisted of numerous rectangular portions. Its investing membrane is very thin, and its substance consists of a syncytium with its nuclei irregularly scattered, and traversed by numerous fine, transverse, muscular fibres (Pl. XXIII, fig. 3).

According to my observations on *Tr. sinuatum*, the species to

which I have mainly directed my attention in this respect, the arrangement of the muscular fibres of the posterior sucker is somewhat different from that described by Niemie.<sup>1)</sup> The fibres may be distinguished into four groups. (1) The *radial* fibres. These must again be distinguished, as in *Calicotyle*, into two subgroups: (a) those that are direct continuations of the longitudinal fibres of the body, and entering the sucker, diverge irregularly in all directions, and are inserted to the periphery of the sucker. They moreover cross each other in the stalk of the sucker; those coming from the two sides of the body going to the opposite sides of the sucker (Pl. XX, fig. 5). (b) Those fibres that are confined to the radiating spokes. These start from the margins of the central polygon, and running in small bundles along the spokes just under the investing membrane, are inserted, likewise, in the periphery of the sucker (Pl. XX, fig. 7, *rad. mus. b.*). (2) The *circular* fibres, *i. e.*, those that run concentrically with the circumference of the sucker. This group must also be divided into two sub-groups. (a) Those that belong to the ventral side. These are arranged in two sets, an outer and an inner. The fibres of the outer set are arranged in a single layer; while those of the inner set are united into strong bundles, which are separated from one another by the transverse fibres to be described presently, and from the outer set by an intervening layer of mesenchyma (Pl. XX, fig. 6, *cir. mus.*). The circular fibres of the dorsal side are arranged in a single layer, and occupy an exactly similar position to that of the outer set of the ventral side. (3) The *transverse* fibres, *i. e.*, those that traverse the thickness of the sucker, and run therefore at right angles to its two surfaces. They are, in *Tr. sinuatum*, very strongly developed, and, like

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1). Niemie—Recherches morphologiques sur les ventouses dans le règne animal. Recueil zoolog. suisse. T. II, 1835. I have not been able to gain access to this paper, and am indebted for its account to Braun's "Wärmer" in Bronn's "Klassen u. Ordnungen" and to Monticelli's "Saggio di una morfologia dei Trematodi."

the dorso-ventral fibres of the body, ramify towards their ends (Pl. XX, figs. 5, 6, and 7). (4) The last group of fibres is confined to the radial elevations, and simply traverse these from side to side, just as the transverse fibres do the sucker (Pl. XX, figs. 5 and 6). These fibres are absent where three elevations unite (Pl. XX, fig. 4).

*Epidella*—I have been able to obtain but few specimens of this genus, and these were so badly preserved that I have not been able to make out the minute anatomy of the various parts; but a few points will be noted.

The *anterior* suckers occupy nearly the same position in the body as in *Tristomum*. They are, however, not so well developed as in that genus, and are more of a membranous character. The two suckers are also united with each other by a membranous anterior portion of the body that lies between them.

The *posterior* sucker is either circular or elliptical in outline, and is provided with a marginal membrane. There is no division of the ventral surface into separate areas as in *Tristomum*. The musculature consists of the circular (in two sets, dorsal and ventral), the transverse, and the irregular radial fibres which are direct continuations of the longitudinal fibres of the body; and these various fibres are arranged exactly like those of the same name in the posterior sucker of *Tristomum*.

STICKY GLANDS—Under this head I include all those glands which are present in various parts of the body and are not intimately connected either with the genital organs or the digestive system. They all open on the free surface of the body, and some of them are closely connected with the suckers.

*Microcotyle* and *Octocotyle*—In all the species of these two genera that I have studied, except *M. reticulata*, there are three groups of sticky glands in the anterior part of the body in front of the

anterior suckers. One of them lies in the median line near the apex of the body, while the other two are situated behind it in a pair, so that the three occupy the apices of an isosceles triangle, the base of which is perpendicular to the long axis of the body. In some species, however, they are nearly in the same straight line (Pls. I and II). In section, each group is seen to consist of a limited number (5—7) of goblet-shaped bodies with a thin wall, and filled with numerous refringent granules of a yellowish colour, which do not stain at all in borax-carmin and only slightly in haematoxylin. It is, however, to be noted that their affinity for the latter dye varies according to different stages of secretory activity. The necks of the goblet-shaped bodies of each group open together on the ventral side (Pl. III, fig. 7). I have not been able to observe any nuclei in them; but I believe they are to be regarded as highly modified cells, and each group, therefore, as an assemblage of unicellular glands.

These glands have been observed by previous writers, but their nature has been variously misunderstood. Van Beneden and Hesse,<sup>1)</sup> for instance, describe them as being “destinées à remplir les fonctions de mâchoires.” Lorenz<sup>2)</sup> on the other hand, considers them as tactile organs. Parona and Perugia<sup>3)</sup> are of the same view. “seguendo in questo il modo di pensare del Diesing e non quello di v. Beneden ed Hesse.” Now, the bodies in question are not situated in the cavity of the mouth as v. Beneden and Hesse think, and their glandular nature is, I believe, evident from their structure above described.

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1). V. Beneden et Hesse—Recherches sur les Bdellodes et les Trématodes marins, 1853. p. 113.

2). Lorenz—Ueber die Organisation der Gattungen Axine u. Microcotyle. Wiener Arbeiten, Bd. I, Hft. 3, 1878. p. 24.

3). Parona e Perugia—Res ligusticae, XIV.—Annali del Museo Civico di Storia Naturale di Genova, Ser. 2, Vol. X, 1890. Estratto p. 4.

*Axine, Diclidophora, & Mic. reticulata*—In these forms, there is only one pair of sticky glands. They are situated just in front of the mouth (Pl. I, fig. 5 ; Pl. VII). Their form differs much from that described in *Microstyle* and *Octocostyle* and approaches more that of the sticky gland described by me in *Diplozoon Nipponicum*.<sup>1)</sup> They are constituted, namely, by an invagination and transformation of the investing membrane of the body. They are shown in section in fig. 3, Pl. III. As may be seen from it, the cavity of the invagination is lined by a granular mass, which is a direct continuation of the investing membrane. The granules are very similar in appearance and in their reaction towards staining fluids to those of the sticky glands of *Microstyle*. Here, moreover, there is no distinct basement membrane but instead merely a dense layer of connective tissue gradually passing into the surrounding mesenchyma. There are in *M. reticulata* also some muscular fibres that come from the dorsal side of the body and terminate in the dense layer of connective tissue just mentioned (Pl. III, fig. 3).

*Calicostyle*—In this genus, there are two pairs of sticky glands at the anterior end of the body, the efferent ducts of which are completely separate one from the other, but open very close to each other near the anterior apex of the body. Each gland is a goblet-shaped, hollow body situated on the external side of the pharynx, with a long neck (the efferent duct) which proceeds towards the anterior end of the body, where it opens. One of the pairs has a little shorter neck than the other. The goblet-shaped portion has a thick wall consisting of a granular substance, which, in the specimen I have examined, is stained well in borax-carmin ; but as I have been able to obtain only a single specimen of this genus, I can not state whether it is always so or not. The wall of the efferent duct consists of a thick membrane.

1). Goto—On *Diplozoon Nipponicum*, n. sp. This Journal, vol. IV, Pt. I, 1890. p. 166.

on the inner surface of which some granulations are to be observed (Pl. XIX, figs. 1 and 4).

As to the cellular structure of this gland, which I believe is here described for the first time in *Calicotyle*, there are, I think, two alternative views to be considered. One would be to regard it as being multicellular in its origin and to have been formed by the invagination of the epidermis; the other would be to regard it as unicellular. Against the second view it may be urged that these glands are too large to be regarded as unicellular—incomparably larger than the unicellular glands of similar function and position of the *Gyrodactylidae*—and that the presence of the internal cavity strongly points to the other view; while the similarity of its wall to that of the similar glands of *Diplozoon*, *Aeine*, and *Diclidophora* is also in favour of the first view.

*Monocotyle*—In this genus there are four pairs of sticky glands at the anterior end of the body, and one in the posterior part. The anterior glands are of exactly the same structure as those of *Microcotyle*, and are arranged at equal distances along the front part of the lateral border of the body, on both sides of the anterior notch (Pl. XVII, fig. 1).

The posterior sticky glands are situated in that part of the body which lies dorsally to the posterior sucker, and consist of numerous small cells, each with a distinct, deeply stained nucleus and a very finely granular or almost homogeneous cytoplasm which seems to be destitute of an external membrane. The cells are of various sizes, apparently owing to the different stages of secretory activity; and the smaller ones are more deeply stained and have more finely granular cytoplasm than the larger ones (Pl. XVII, figs. 5 and 12). In some parts, these cells are so closely pressed against one another that their boundaries become indistinct, and the whole appears somewhat like a



syncytium (Pl. XVII. fig. 6). They are distributed, both on the ventral and dorsal sides (Pl. XVII. fig. 5), into two groups, the right and the left; and the cells of each group discharge their products into a common large duct<sup>1)</sup> provided with a distinct membrane, which opens by a minute aperture on the ventral surface of the lateral portion of the body, at a short distance from the stalk of the sucker (Pl. XVII. fig. 12. *gl'*). The secretion of these granular cells is a very granular fluid, the granules staining very deeply in haematoxylin.

*Tristommum* and *Epibdella*—As has already been observed by Monticelli,<sup>2)</sup> there are, in these genera, numerous unicellular glands in the anterior portion of the body; and in some species of *Tristommum* (*T. sinuatum* and *T. biparasiticum*) there is in addition a series of groups of unicellular glands which open at regular intervals along the lateral borders of the body.

The cells of the anterior sticky glands are more or less goblet-shaped, with a very thin membrane, a more or less granular cytoplasm, a nucleus with a single nucleolus, and a long neck. The nucleus sometimes occupies the central position, but is sometimes quite peripheral. The cells are distributed almost uniformly, or in groups separated from one another by dorso-ventral muscular fibres, in the mesenchyma of the suckers and of the anterior, median portion of the body. In some species of *Tristommum* (as in *T. orale*) the necks of the gland-cells open at various points on the ventral surface of the sucker, at the tops of small, conical papillae (Pl. XXII. fig. 5), and especially along the inner border of the sucker, where the papillae are, as already mentioned, larger and very numerous (fig. 5). In *T. sinuatum* the glands open mainly along the margin of the anterior

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1). Its size, however, probably varies according to the quantity of its content.

2). Monticelli—Di alcuni organi di tatto nei Tristomidi: Bollet. della Soc. di Naturalisti in Napoli, Ser. 1, Anno 5, vol. V., 1891, fasc. 2.

sucker, on the ventral side, where the basement membrane is somewhat indistinct; but they probably open also on the whole ventral surface, although I can not make a positive statement to that effect (Pl. XX, fig. 10). In *Epibdella*, on the other hand, the glands open on the whole ventral surface of the anterior sucker. Here, however, it should be remarked that in most cases I have not been able to follow the neck of the gland-cells *through* the investing membrane of the body to the external surface, but only *up to* the basement membrane. In *T. orale*, on the other hand, the opening of the glands are distinctly seen at the top of most of the conical papillae already mentioned. This leads me to suppose that the ducts of the glands through the investing membrane is usually entirely collapsed, being open only during the actual passage of the secretion. It also leads me to suspect whether Brandes<sup>1)</sup> has not mistaken these glands for his "subcuticular glands."

In two species of *Tristomum*, viz. *T. sinuatum* and *T. biparasiticum*, there is, as before mentioned, a series of groups of peculiar unicellular glands opening at intervals along the lateral margin of the body. The series begins near the anterior end of the body, and terminates quite near the posterior sucker (Pl. XX, fig. 1; Pl. XXV, fig. 5). In *T. sinuatum* I have counted as many as fifty-eight on one side of the body, while in *T. biparasiticum* there were about sixty-two. I have studied the histology of these glands mainly in the former species, so that the following statements refer mainly to it alone; but the essential features are the same in both species, the difference lying only in insignificant details.

The cells that constitute these glands are of various sizes, but are more or less polyhedral in form, owing to mutual pressure. Each cell has a distinct wall, and in the specimens I have examined, the greater

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1). Brandes—*l. c.*

part of its interior was occupied by one or more clear vacuoles. The nucleus, which enclosed a single nucleolus, sometimes occupied a central position, but usually lay more or less towards the periphery of the cell; and in most cases was surrounded by a mass of granular cytoplasm, which was stained in hæmatoxylin more deeply than the nucleus itself. From this central mass the cytoplasm radiated, in most cases, in the form of a few threads towards the cell-wall (Pl. XXI, figs. 2 & 3). Each cell is prolonged at one of its corners into a long duct; and the ducts of a single group, after proceeding together for a short distance towards the lateral border, are divided into two bundles, which diverge from each other, and again unite just before opening on the dorsal surface of the body, close to its lateral margin.

From the above description, the glandular nature of these cells is, I believe, beyond doubt; and comparing them with the cells of the submaxillary glands<sup>1)</sup> of the mammalia, there is such a similarity between the two that it is perhaps allowable to conclude that these unicellular glands secrete mucin and help to attach the body of the parasite more securely to its host.

The opening of the gland above described is armed with a chitinous piece, which is represented in surface view in fig. 3, Pl. XX, and in section in its natural position in fig. 3, Pl. XXI for *T. sinuatum*, and in fig. 5, Pl. XXV, for *T. biparasiticum*. In *T. rotundum* similar chitinous pieces (Pl. XXIV, fig. 7) are arranged in transverse rows along the lateral margin of the body just as in *Tr. mola*<sup>2)</sup>; a single row consisting of four or five pieces in the middle portion of the body, but of only one or two towards the ends. In this species,

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1). Landois.—Lehrbuch der Physiologie des Menschen. 6. Aufl. p. 268-270.

2). Parona e Perugia.—Res. ligusticæ, VIII. Di alcuni trematodi ectoparassiti di pesci marini. Nota preventiva. Annali del Museo Civico di Storia Naturale di Genova. Ser. 2, vol. VII. p. 711.

however, there is no gland connected with these chitinous pieces.<sup>1)</sup> These pieces might be supposed to help the parasite in attaching itself to the host, were it not for the fact that they are on the dorsal side of the body, and are therefore presumably of no use in that respect; but I am not able to suggest any other use of them.

If, now, we compare the structure of the glands hitherto described, we find a close similarity of their products with one another as well as with those of the sticky glands of *Gyrodactylidae*. The clear, transparent fluid that fills the vacuoles of the lateral glands of *T. sinuatum* and *T. biparasiticum* might be mentioned as exceptions; but we find in their efferent ducts just the same granular substance as in the anterior glands, showing probably that the clear contents of the cells assume the character of granules in their passage along the duct. That the anterior glands of *Gyrodactylidae* are sticky, and are used for attachment can be demonstrated under the microscope; so that I believe it is not much amiss to regard, as I do, the glands above described as having the same function. It may also be mentioned, in addition, that Langley<sup>2)</sup> and Reid<sup>3)</sup> have described granules in the mucous glands of some vertebrates, which seem to me in many respects similar to those of the glands above described.

It is not perhaps out of place here to observe that the position of the opening of the posterior sticky glands of *Monocotyle* does not seem

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1). Here, again, it should be observed that these so-called chitinous pieces of *T. rotundum* are deeply stained in borax-carmin.

2). Langley—On the Histology of the Mucous Salivary Glands, and on the Behaviour of their Mucous Constituents. Journ. of Physiology. Vol. X, 1889. p. 433-457.

3). Reid—Mucin Granules of Myxine. Same Journ. Vol. XIV, 1893. p. 340-346.

These authors state that the granules are not stained in haematoxylin, and that cold sublimate causes them to burst. This latter fact seems not to accord with the observations described in the text, in which the granules are always preserved intact. Reid also states that boiling water makes the granules break into a mass of stringy debris. Hence we should probably infer that the granules of the glands described in the text and those of the mucous glands of the vertebrates are not exactly of the same chemical constitution.

to accord with their supposed function. *A priori*, the opening might be expected on the ventral surface of the sucker; but as the matter stands, I suppose the secretion of the glands flows over the dorsal surface of the sucker on to its margin, and here helps to attach it more firmly to the host.

The two genera *Hexacotyle* and *Onchocotyle* are destitute of any sticky gland.

Hooks<sup>1)</sup>—These are usually spoken of as of a chitinous nature; but it should be remembered that they are soluble in a (35 %) solution of caustic potash. In the natural state they are slightly yellow, and are very refringent. When they are very slender they are wholly solid; but when somewhat large they are usually hollow. They lie mostly imbedded in the mesenchyma, and only a very small portion of the pointed end projects free on the surface of the body. Their form, size, number, and position are very varied, but are eminently characteristic of each species.

In *Onchocotyle*, *Tristomum*, *Monocotyle*, *Calicotyle* and *Octocotyle major* there is only a single pair of hooks. In the last-mentioned species, they are situated at the posterior end of the body between the posterior suckers, close to the median line. They have roughly the form of a fishing hook, and have a process at about the middle of their length, to which is attached a strong bundle of muscular fibres (Pl. IX, figs. 2 & 9 a). In the natural position the pointed end is usually directed posteriorly, but is turned more or less in other directions according to the different states of contraction of the muscle attached to the hook. In *Octoc. major* the hooks are hollow towards the pointed end (Pl. IX, fig. 2); but in *Octoc. minor* they are entirely solid (fig. 9 a).

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1). For more minute descriptions of the hooks in different species see the systematic portion of the present paper.

In *Onchocotyle*, the hooks are situated near the extremity of the caudal appendage, between the pair of small suckers already described, on the morphologically ventral side (Pl. XV, figs. 1 and 2). They are wholly solid, and are like a fishing hook in shape; but the basal end is divided into two processes, one of which bears again a rounded process (Pl. XV, fig. 5). I have not been able to demonstrate any muscular fibres attached to the hooks.

In *Tristomum*, the hooks are situated at the extremities of the posterior border of the central polygon of the posterior sucker, and are provided each with a strong muscle formed by the direct continuations of the longitudinal fibres of the body. They are, unlike the hooks of most other genera, more or less straight (Pls. XX, XXIII, XXIV, XXV).

In *Calicotyle* and *Monocotyle*, the hooks are situated in the posterior radial spokes of the posterior sucker on both sides of the median line of the body, and project free over the surface of the investing membrane at the margin of the sucker (Pl. XVII, figs. 1 and 2; Pl. XIX, fig. 1). They are strongly recurved in both genera.

In *Hexacotyle* and *Octoc. minor*, there are two pairs of hooks, of which one is much smaller than the other. They are situated at the posterior end of the body, on both sides of the median line, and between the innermost pair of suckers in *Hexacotyle*. In both cases the smaller pair of hooks lie nearer the median line (Pl. IX, fig. 7; Pl. XIII, figs. 1, 2, 4, & 5).

Finally in *Epibidella*, there are three pairs of hooks. They are situated on the ventral side of the posterior sucker, and the three pairs are arranged one behind the other; the most posterior pair being close to the margin of the sucker. Each hook is provided with a strong bundle of muscular fibres.

The genera *Microcotyle*, *Aciue*, and *Diclidophora* are, so far as I have observed, entirely destitute of hooks.

### 5. The Mesenchyma.

The mesenchyma of the Trematodes has been variously described by different authors. The fact is that it presents very different aspects in different species and even in different parts of the same specimen. The mesenchyma of the monogenetic Trematodes is, generally speaking, of very different appearance from the typical form of the same tissue in the Digenea, which consists of large vacuolated cells, between which fibrous network with small nuclei is present<sup>1)</sup>; and varies from a truly cellular character to that of the typical, reticulated, fibrous connective tissue on the one hand and a true syncytium on the other.

The general mesenchyma of the body has been distinguished by certain writers into two parts, for which different names have been proposed by different writers, but the terms proposed lately by Brandes,<sup>2)</sup> *viz.* endo- and ectoparenchyma are the simplest and therefore the most convenient. In *Axine heterocerca* these two portions are very distinctly separated from each other by a thin membrane of compact connective tissue, and are very different in character (Pl. VIII, fig. 1). The ectoparenchyma is, in this species, again distinguishable into two layers, that in which the longitudinal fibres lie and that in which the diagonal and the circular fibres run. The inner layer, *viz.* the one in which the longitudinal fibres run, is, in some places, as thick as 20  $\mu$ , and its connective tissue consists of very fine, anastomosing fibres, which are but slightly stained in haematoxylin, and in the knots of which nuclei are here and there present. The general course of the connective tissue fibres of this layer is at

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1). Leuckart—Die thierischen Parasiten des Menschen. II. Aufl., I. Bd., 3. Lief., p. 13 *et seq.*

2). Brandes—*l. c.*, p. 124.

right angles to its limiting membrane, and in some places, the fibres form somewhat strong, compact bundles, which are more deeply stained than the other parts. The outer layer, *viz.*, that in which run the diagonal and the circular muscular fibres, is generally half as thick as the inner layer. It consists of dense, fibrous connective tissue, scantily interspersed with nuclei and deeply stained by haematoxylin. This layer is, in most parts of the body, very distinct from the inner layer, from which it seems to be separated by a very thin membrane; but in some parts, the two layers are not so distinctly separated from each other (Pl. VIII, fig. 3).

In *Microcotyle reticulata*, also, the external portion of the ectoparenchyma is clearly distinguishable from the inner; the former consisting, in fact, of a dense, diffusely stained, connective tissue, whose fibres run parallel to the investing membrane (Pl. III, fig. 4).

In all the other species I have hitherto studied, the ecto- and endoparenchyma are not separated from each other so distinctly as in *Aeine heterocerca*; but in most species the two portions present different aspects, the ectoparenchyma consisting generally of a dense, fibrous, connective tissue which is more deeply and more diffusely stained with haematoxylin than the endoparenchyma. There is, however, as above stated, no distinct landmark that separates the two from each other, and even in *Aeine heterocerca* there is no distinct boundary between them towards the two ends of the body.

The endoparenchyma presents, in most species, different aspects in different parts of the body. In *Aeine heterocerca* (Pl. VIII, fig. 1), the endoparenchyma is, in most parts of the body, of a cellular nature. The cells which are of very different sizes in different parts, have usually a distinct membrane and a deeply stained nucleus enclosing mostly a single, but sometimes two or more nucleoli. The cell-body encloses some large vacuoles, and the protoplasm



radiates, in consequence, in the form of threads from around the nucleus towards the cell-membrane. In some cases, however, there are no vacuoles, and the cell-body consists simply of a slightly stained, granular protoplasm. In still other cases (*e.g.*, on the right side of the prostate glands around the vas deferens in fig. 1, Pl. VIII), the cell-membrane is incomplete, and the boundaries of adjacent cells are more or less obliterated. In the terminal portions of the body as well as around the ducts of the genital organs, the endoparenchyma consists of truly fibrous connective tissue interspersed with small nuclei, which are sometimes surrounded by a scanty mass of granular protoplasm. Around the ducts of the genital organs I have often observed much larger, oval or elongated nuclei surrounded also with a scanty mass of granular protoplasm; but they seem to have no special function. The meshes of the connective tissue are filled in some parts with slightly stained granules and in others with a perfectly transparent, clear fluid (Pl. VIII, figs. 2, 3, and 4).

In most species of *Microcotyle*, the greater part of the endoparenchyma is of a fibrous nature; but in some parts it consists of true cells, while in others there is some tendency in it to assume the character of a syncytium. Thus in *Microcotyle truncata* (Pl. III, fig. 6) and *M. caudata* (Pl. III, fig. 9), the endoparenchyma consists in the lateral part of the median portion of the body free from the vitellarium, often of polyhedral cells each usually with a distinct membrane, a vacuolated cell-body, and a nucleus in the centre, from which the protoplasm radiates in the form of fibres towards the periphery, just as in some mesenchyma cells of *Axine* already described. In *M. caudata* the vacuoles are less distinct, and the whole cell is more granular and more deeply stained than in *M. truncata*. The nucleus usually encloses a single nucleolus, but sometimes more; and the boundaries of the adjacent cells are, in many cases, more or

less obliterated, as may be seen in the figures above referred to. In *M. reticulata*, the endoparenchyma of which consists generally of a typical, reticulated fibrous connective tissue, there are scattered here and there, sometimes in small groups, cells of a roundish or polyhedral outline, with a distinct membrane and a lightly stained, granular protoplasm (Pl. III, fig. 4, *mes. c.*). Besides these, vacuolated cells whose boundaries can be recognized with difficulty are also to be observed. In *Diclidophora sessilis*, I have observed in the neighbourhood of the ovary, large vacuolated cells with a centrally situated nucleus, from which granular protoplasmic threads radiated towards the cell-membrane (Pl. XI, fig. 7)—cells, therefore, which are very similar to those of the mesenchyma of many distomes. In this species there are also polyhedral cells similar to those described in *M. truncata* and *M. caudata*, between the lateral and the median portion of the body (Pl. XI, fig. 5). In *M. chiri* (Pl. III, fig. 5), *M. elegans* (Pl. V, fig. 2), *M. sciaenae* (Pl. VI, fig. 2), *Calicotyle Mitsukurii* (Pl. XIX, fig. 8), *Monocotyle Ijima*e (Pl. XVIII, fig. 2), *Onchocotyle spinacis* (Pl. XV, 10; Pl. XVI, fig. 8), and *Tristomum orale* (Pl. XXIII, fig. 7), and in those portions of the body of *M. fusiformis* and *M. caudata* which adjoin the genital opening, the endoparenchyma consists of a reticulated, fibrous connective tissue with large meshes filled with granules which are in some species faintly, but in others well stained (Pl. V, figs. 1, 2, and 3)—the mesenchyma assuming in the latter case more the character of a syncytium. In some species moreover, as in *Onchocotyle spinacis*, the nuclei are generally surrounded by a scanty mass of granular, well-stained protoplasm.

In *Hexacotyle acuta*, the greater part of the endoparenchyma consists of cells apparently destitute of any membrane, but with well-stained, granular protoplasm, and each with a distinct nucleus which encloses one or a few nucleoli. These cells are usually separated from

one another by intervening spaces which in sections appear perfectly colourless ; but in many cases the protoplasm of adjacent cells is continuous, and no boundary can be recognised between them (Pl. XIV, fig. 2). In *Hexacotyle grossa* (Pl. XIV, fig. 6) and *Tristomum sinuatum* (Pls. XXI and XXII), the endoparenchyma is a true syncytium traversed, however, by scattered connective tissue fibres. The nuclei are very irregularly distributed ; and in both species they are much smaller than in others. In *Hexacotyle grossa* I have observed, scattered here and there apparently without order in the general syncytium, cells of irregular forms, with a homogeneous protoplasm which was well stained by haematoxylin, but differently from the general syncytium (Pl. XIV, fig. 6. x), which was stained deep blue, while the cells above mentioned were stained purplish red, just the colour of acetic haematoxylin. I have occasionally observed similarly stained cells in *Onchocotyle spinacis*. These cells have, so far as I have observed, no relation with the glands hitherto described or to be described hereafter ; and the only suggestion that I can give as to their nature is that they are perhaps worn-out cells undergoing disintegration, and that their colour is due to the presence of some acids generated by decomposition. In *Tristomum sinuatum*, I have often observed in the peripheral portion of the endoparenchyma cells (already referred to in describing the investing membrane) of a rounded outline and with a granular protoplasm. I do not know what else they are than remnant cells of the original mesenchyma.

Around the terminal portions of the genital ducts, the mesenchyma is specially modified in various ways. These will be treated of in connection with the genital organs.

If, now, we make a general survey of the various forms of endoparenchyma found in the monogenetic Trematodes, we see that even in the same species it is very different in different parts of the

body, while individual variations in this respect may be almost imperceptibly small. Near either end of the body the endoparenchyma consists, in almost all species, of typical, fibrous, reticulated, connective tissue, interspersed with nuclei (Pl. II, fig. 7; Pl. IV, fig. 2; Pl. XII, figs. 4 & 7; Pl. XV, fig. 8; Pl. XVI, fig. 1). In other parts of the body we may distinguish two different tendencies in the course of differentiation of the original mesenchyma cells. Some of these cells appear to assume more of a vacuolated character, and these furnish the fibres of the connective tissue; while others come to have more and more a granular protoplasm without any distinct membrane, and to form finally a continuous syncytium by simple obliteration of their boundaries. These two tendencies prevail in different degrees in different parts of the body, and also in different species. An endoparenchyma of a typical, reticulated, connective tissue we have found in *Microcotyle sciænae*, *Calicotyle Mitsukurii*, and in the terminal portions of the body of many other species; that of a true syncytium we have found in *Tristomum sinuatum* and *Hexacotyle grossa*; while in all the other species the syncytial and fibrous characters are variously intermingled.

### 6. The Digestive System.

The digestive system consists of the mouth and its cavity, the pharynx, the oesophagus, the intestine, and the glands which are connected with them.

The *mouth* is a funnel-shaped opening situated, in all the species, on the ventral side near the anterior extremity of the body. In *Microcotyle*, *Acline*, *Onchocotyle*, *Dictidophora*, *Octocotyle*, and *Hexacotyle*, it is close to the anterior end of the body; while in *Tristomum*, *Epibdella*, *Monocotyle*, and *Calicotyle* it is more distant from it. In most species there is a tolerably ample mouth-cavity; and in those forms

which have paired anterior suckers within the mouth ("Mundsaug-näpfe" of Braun), it freely communicates with the cavities of the latter. In *Microcotyle* (Pl. IV, figs. 1 and 2), *Octocotyle*, *Diclidophora*, *Onchocotyle*, and *Hexacotyle*, the mouth-cavity expands more or less at its posterior end and constitutes the *prepharynx*, into which the anterior end of the pharynx protrudes. In *Tristomum* and *Epibdella*, however, the mouth and the anterior end of the pharynx coincide so that in these there is no mouth-cavity (Pl. XXI, fig. 1; XXIII, fig. 4; XXIV, fig. 12; XXV, fig. 7).

The *pharynx* is more or less ellipsoidal or almost spherical, or it may have a constriction on each side, so that in horizontal optic section it appears double, as in many species of *Tristomum* (Pl. XXIII, fig. 1; Pl. XXIV, fig. 10; Pl. XXV, figs. 1 and 4). In *Microcotyle*, *Octocotyle*, *Diclidophora*, and *Onchocotyle*, it is traversed by a small, tubular canal which puts the oesophagus in communication with the cavity of the mouth, and is lined by a structureless membrane of various thickness according to the species. In *Monocotyle*, the cavity of the pharynx is triangular in cross-section (Pl. XVIII, fig. 8); while in *Tristomum* and *Epibdella*, it is funnel-shaped and spacious. Considering this internal cavity as the axis for the sake of orientation, we may distinguish the ventral and dorsal halves of the pharynx; and the ventral half thus distinguished is always smaller than the other half—resembling in this respect the oval anterior sucker of *Onchocotyle* and the distomes (Pl. IV, fig. 1; Pl. XV, fig. 3; Pl. XVIII, fig. 4; Pl. XXI, fig. 1; Pl. XXIII, fig. 4; Pl. XXIV, fig. 12; Pl. XXV, fig. 7). In nearly all species, the pharynx is an independent organ entirely separated from the surrounding mesenchymatous tissue by a distinct membrane of a cuticular appearance. In *Tristomum*, however, this membrane is incomplete at some points at the posterior ends of the ventral and dorsal halves, and thus affords passage to the

efferent ducts of the numerous glandular cells presently to be described. The internal cavity is in some species lined with a comparatively thick, structureless membrane of varying thickness, staining well with haematoxylin, as in most species of *Microcotyle*, *Dictidophora* (Pl. XI, fig. 1), and *Monocotyle* (Pl. XVIII, fig. 8); but in others the lining membrane is exactly similar to that which separates the pharynx from the surrounding mesenchyma. The greater part of the substance of the pharynx consists of mesenchymatous connective tissue essentially similar to that of the other parts of the body and traversed by numerous muscular fibres—the muscular fibres, however, predominating sometimes to an extraordinary degree and forming almost the whole, as in *Monocotyle* (Pl. XVIII, fig. 8) and *Microcotyle reticulata* (Pl. IV, figs. 2 and 3).

The musculature of the pharynx consists typically of three sets of fibres, *viz.* the *internal* and *external circular* fibres and the *radial* fibres. In most species, the sets of circular fibres are arranged in a single layer directly inside the limiting membranes of the pharynx; but in some species they are more than one layer thick, as in *Tristomum sinuatum* (Pl. XXI, fig. 1) and *Dictidophora sessilis* (Pl. XI, fig. 1). Moreover in all the species of *Tristomum* I have studied, these two sets of circular fibres are developed in a special degree at the anterior end of the pharynx, and constitute a powerful sphincter (Pl. XXI, fig. 1; Pl. XXIII, fig. 4; Pl. XXIV, fig. 12; Pl. XXV, fig. 7). The radial fibres are but weakly developed in *Microcotyle*, *Axine*, *Octocotyle*, and *Onchocotyle*; indeed, in the last-named genus I have not been able to demonstrate their existence with enough certainty. In *Tristomum*, *Monocotyle*, *Dictidophora*, and *Microcotyle reticulata*, however, they are more strongly developed. Like the dorso-ventral fibres of the body, the radial fibres divide into smaller branches towards their ends, and are inserted into the limiting membranes of the pharynx.

Between these radial muscular fibres there are numerous nuclei, some of which are exactly similar to those of the general mesenchyma of the body ; but there are also others which are much larger and are usually surrounded by a granular protoplasm (Pl. XI, figs. 1 and 2). These I believe to be remnants of cells that have produced the muscular fibres.

The arrangement of the muscular fibres of the pharynx is in most species as above described ; but there are numerous departures from the rule. For instance, in *Diclidophora sessilis* there are longitudinal (or meridional) fibres on the ventral side, occupying a short strip along the median line. In *Microcotyle reticulata*, again, the various sets of muscular fibres and their arrangements are so anomalous that they require separate description. They may be conveniently distinguished into the *longitudinal*, the *circular*, and the *oblique* fibres. The circular fibres must again be divided into two groups, the internal and the external. The *internal circular* fibres are situated next the lining membrane of the pharynx at a short distance from it (Pl. IV, figs. 2 & 3, *int. c. m.*). They are most strongly developed a little behind the middle of the length of the pharynx, and diminish towards either end. They are divided into strong, compact bundles by the radial fibres, which pass between them and are inserted into the lining membrane of the pharynx. The *external circular* fibres are present along nearly the whole length of the pharynx, but are especially developed in its posterior half, and are there more numerous than the inner fibres, which they resemble in being divided into numerous, compact bundles by the radial fibres. In the anterior half of the pharynx they are less developed, and are divided into smaller bundles by the oblique fibres to be presently described. In the lateral part of the pharynx the external circular fibres are situated about midway between the inner and the outer limiting membrane of the pharynx ;

but in the dorsal and ventral parts, they are situated directly inside the external limiting membrane (Pl. IV, fig. 2). Some of the external circular fibres deviate more or less from their course, and passing between the bundles of the lateral longitudinal fibres, are inserted into the external limiting membrane. The *longitudinal* fibres are divided into three groups, which may be called according to their relative positions, the internal, the middle, and the external. The *internal longitudinal* fibres are present only in the posterior third of the pharynx, and are situated between the inner limiting membrane and the inner circular fibres (Pl. IV, fig. 3, *d*). They do not form any definite bundle, and are inserted by their ends into the inner limiting membrane of the pharynx. The *middle longitudinal* fibres are arranged in a single layer directly on the outer side of the inner circular fibres, with which they are intimately associated throughout their whole course (Pl. IV, figs. 2 and 3, *c*). The individual fibres of this group are separated from one another by an intervening space, and have a round outline in cross-section. The *outer longitudinal* fibres are present only in the posterior two-thirds of the pharynx, and are divided into four groups, crescent-shaped in cross-section, and placed symmetrically in the lateral, dorsal, and ventral parts (Pl. IV, figs. 2 and 3, *b* and *b'*). The lateral groups are situated directly inside the external limiting membrane of the pharynx; but the dorsal and ventral groups are separated from it by the external circular fibres already described. The constituent fibres of these groups are formed into strong, compact bundles, which are separated from one another by the radial fibres and also to some extent by the external circular fibres (fig. 2). They are inserted, posteriorly into the lining membrane at the end of the pharynx and more anteriorly into the external limiting membrane at various points.



There is another peculiarity in the pharynx of *M. reticulata*, and that is that its anterior end is prolonged into a tube with pointed end and with a thick wall which is differentiated into two layers unstained by borax-carmin, the outer of which is very refractive. Both these layers are homogeneous and without structure.

In all the species of *Tristomum* that I have studied, there are numerous papillae on the surface of the cavity of the anterior half of the pharynx; and in some species, as in *Tr. orale* (Pl. XXIII, fig. 4) and *Tr. sinuatum* (Pl. XXI, fig. 1), these papillae are present also at the anterior margin. They mark the openings of numerous unicellular glands, which have been called "Körnerdrüsen" or "Pharyngealdrüsen" by Max Braun.<sup>1)</sup> I shall adopt the latter name and call them pharyngeal glands. The glandular cells themselves are situated, so far as I have observed, not as Braun states, in the wall of the pharynx, but outside it, that is, in the mesenchyma of the median portion of the body behind the pharynx, as may be clearly seen in fig. 5, Pl. XXI, which represents a horizontal section of the region in question in *Tr. sinuatum*. They are very numerous, and vary in form from a typical goblet to a more or less oval or polygonal shape. The goblet-shaped cells, the comparatively large efferent ducts of which can be generally traced very distinctly to the wall of the pharynx, have vesicular nuclei each with one or more, faintly stained nucleoli; both the cell-body and the efferent duct are entirely filled with coarse granules which stain but slightly with haematoxylin. On the other hand, those which are oval or more or less polygonal in form have each a rather small nucleus with a single, deeply staining nucleolus; and the cell-body is very finely granular and deeply stained (Pl. XXI, fig. 5). Both these and the goblet-shaped cells seem to be entirely destitute of a membrane.

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1). Braun—"Würmer" in Bronn's Klassen u. Ordnungen, p. 450.

Though I have not actually observed it, a number of these efferent ducts seem to unite into one on entering the wall of the pharynx at its posterior part; and they finally open into its cavity at the top of the papillae already mentioned. That two or more ducts unite together I infer from two facts, *viz.* (1) that while only one duct opens at the top of each papilla the total number of these papillae is far less than that of the glandular cells, and (2) that the efferent ducts in the wall of the pharynx are very much larger than those of the single cells. Sometimes also, a portion of the duct is swollen into a reservoir which may present a vacuolated appearance (Pl. XXIV, fig. 12). Moreover, the granules seem to disappear on entering the ducts of the pharynx, and to be agglomerated into a continuous mass; for the contents of these ducts do not present any structure, but consist of a deeply stained substance which has all the appearance of a mucons secretory product. Braun<sup>1)</sup> states that in these glandular pharynges, such as we find in *Tristomum*, the pharyngeal cells or those large cells with a finely granular protoplasm seem to be absent; but although I have found them very few, they do not seem to be entirely absent (Pl. XXIII, fig. 4). At the same time it should be remarked, however, that I have failed to recognise the terminal cells of the excretory system, which are stated by Braun to be present in the pharynx.

The cavity of the pharynx leads into the *oesophagus*. This is in most species simple and tubular in form; but in some species, as in *Axine heterocerca*, *Microcotyle reticulata*, and *Hexacotyle*, it sends out lateral branches on both sides, the ends of which are in *M. reticulata* all connected together by a longitudinal branch of the intestine (Pl. III, fig. 2). In most species of *Microcotyle*, and in *Octocotyle*, *Hexacotyle*, and *Onchocotyle* it is somewhat long; but in all the other species

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1). Braun—*l. c.* p. 450.

I have studied, it is very short or almost entirely wanting. Its internal surface presents just the same aspect as that of the intestine, and therefore will be described with that. In *Monocotyle*, *Calicotyle*, and *Tristomum*, (and probably also in *Epibletta*) numerous unicellular glands open into the oesophagus at its very beginning (Pl. XX, fig. 8; Pl. XXI, fig. 1; Pl. XXIV, fig. 12; Pl. XXV, fig. 7; Pl. XXIII, fig. 4; Pl. XVIII, fig. 5; Pl. XIX, fig. 8), which have been called the *salivary glands*. In *Monocotyle* and *Calicotyle*, they are situated close around the oesophagus, and in the former also a little behind it (Pl. XVIII, fig. 5; Pl. XIX, fig. 8). In *Tristomum*, however, they are situated quite in the lateral portion of the body on the dorsal side, and are connected with the oesophagus by long ducts (Pl. XX, fig. 8). The cells present somewhat different aspects (Pl. XX, fig. 9; Pl. XVIII, fig. 5); they stain well, but in some the cell-body is comparatively finely granular, and the oval, vesicular nucleus encloses in its centre a single, well staining nucleolus, while in others the cell-body is more coarsely granular and the large, round, vesicular nucleus usually encloses a few small nucleoli besides the large one, all of which stain more weakly than in the first class of cells. Cells of the first class also stain more deeply than those of the second. These differences are no doubt due to the different stages of secretory activity; for, intermediate forms of all degrees are also present.

In *Tristomum*, the oesophagus is separated from the intestine by valve-like projections of the surrounding tissue into the cavity of the alimentary canal in which sphincter muscular fibres are present. (Pl. XXI, fig. 1; Pl. XXIV, fig. 12; Pl. XXV, fig. 7; Pl. XXIII, fig. 4).

In *Microcotyle*, *Axine*, *Octocotyle*, *Dictylodora*, *Hexacotyle*, and *Onchocotyle*, the salivary glands are absent.

The oesophagus leads into the *intestine*. This always consists of two branches, which proceed towards the posterior end of the body, where they unite together in some species, or in others remain separate. They traverse the body midway between the dorsal and the ventral side, and divide it lengthwise into three, roughly equal areas, in the central one of which is placed the greater part of the genital organs, while in the lateral areas only the vitellarium is generally present. The two divisions of the intestine send out lateral branches on both sides; but those of the inner side are generally very short, while those of the outer are long and bifurcate repeatedly before reaching the lateral borders of the body. In some again, as in *Hexacotyle* (Pl. XIII), there are, besides the two main branches of the intestine above mentioned, two others which are situated close to the lateral borders of the body, and extend backwards through the anterior two-thirds of the body. In this genus as well as in *Micr. reticulata*, the branches of the intestine form a close net-work not only in the lateral but also in the median portion of the body. The relative arrangements of the main divisions of the intestine as well as of their branches will however be best gathered from the accompanying plates and the description of species, so that I may here pass them over, and proceed to the consideration of the intestinal epithelium.

Two types of intestine may be distinguished according to the character of the cells that constitute its epithelium. In the first type, the cavity of the intestine is destitute of any continuous epithelium, but is bounded directly by a tunica propria, on the surface of which lie cells without any membrane, which contain in their protoplasm numerous, yellowish, dark-brown, or almost black granules of strong refractive power. In most species, there is a distinct nucleus, and in some, as in *Onchocotyle spinacis* (Pl. XV, figs. 7 and 10), also a well

staining protoplasm. In the species just named, the cells are cylindrical, sometimes attaining the length of about .05 mm., and are in some parts closely crowded. But in most of the other species having the intestine of this type, the cells are separated from one another by wide intervals, and the protoplasm is almost entirely obscured by pigment granules. In *Microcotyle* I have not been able to demonstrate the existence of the nucleus, although there was a clear space in the centre of each cell. In *Onchocotyle*, again, there are, besides the tall, cylindrical cells already mentioned, smaller cells with a well staining, finely granular protoplasm which is either entirely destitute of pigment granules or contains fewer granules of smaller size. Some of these cells are again very small, and have a scanty mass of protoplasm around the nucleus, which latter remains nearly constant in size in all the forms of cells. Intestines of the type above described are found in *Microcotyle*, *Acine*, *Otrocotyle*, *Diclidophora*, *Heacotyle*, and *Onchocotyle*.

The second type of intestine is similar to that of the distomes, and is found in *Tristomum*, *Epibdella*, *Monocotyle*, *Calicotyle*, and the *Gyrodactylidae*. In this type, the intestinal cavity is lined by a continuous epithelium consisting of cells which are all similar to one another. The individual cells are either cubical or cylindrical, and have a distinct membrane except on their free borders where it seems to be entirely wanting. The nucleus is always situated close to the tunica propria. In *Monocotyle Ijimai* (Pl. XVIII, figs. 2 and 5), the boundaries of the cells are, in cross-section, not to be clearly seen in every case; but in a surface view they can be distinctly recognised (Pl. XVII, fig. 11). In this species, moreover, the protoplasm of the cells stains deeply, and contains numerous, deeply staining, granules, which are smaller than and also very different in appearance from the pigment granules of the first type. In *Tristomum*, however, the

epithelial cells stain very slightly, are generally very clear, and are also very much smaller than in *Monocotyle*.

Having now described the various parts of the digestive system, I shall proceed to note down a few considerations on the physiology of the accessory glands.

In the first place, as to the pharyngeal glands. As is well known, there are in Turbellaria numerous unicellular glands in the mesenchyma around, before, and behind the pharynx. These open mainly on the lips of the pharynx, but according to Lang<sup>1)</sup> also on the inner and outer surfaces. They have been called the salivary glands. According to Graff<sup>2)</sup>, two sorts of these glands are to be distinguished in *Rhabdocoelida*, viz., those that open into the mouth-cavity (Pharyngealtasche), and those that open into the oesophagus or, where such is wanting, between the pharynx and the intestine, the latter sort alone deserving the name of "echte Speicheldrüsen." Those who have had occasion to observe any turbellarian in the living state will have noticed how firmly it sometimes sticks to the side of the vessel in which it is placed, by means of the pharynx and especially its lips, no doubt by virtue of the secretion of the "salivary glands." Although I have not made any convincing observation on this point, I believe the pharyngeal glands of *Tristomum* serve the same purpose, and assist in attaching the parasite securely to the host. Again, in *Distomum lanceolatum*, unicellular glands with granular contents open on the anterior border of the body. Their secretion is regarded by Leuckart<sup>3)</sup> as having "eine reizende Einwirkung auf die Gewebstheile des Wirthes." The numerous unicellular glands that open into the ventral sucker and on both sides of the pharynx of

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1). Lang—Die Polycladen des Golfes von Neapel. pp. 111, 113, 115, 120.

2). Graff—Monographie der Turbellarien. Rhabdocoelida. p. 99.

3). Leuckart—Die menschlichen Parasiten. II Aufl., I Bd II. Abtheil. p. 366-367.

the *Holostomidae* are regarded by Brandes<sup>1)</sup> as having the same function. As to the action of the pharyngeal glands in *Tristomum* I am not able to say anything definite; at any rate I have not observed any inflammation on the gill of the host, so that I believe they are to be regarded merely as mucous glands.

Next, concerning the salivary glands. These are, in my opinion, clearly to be distinguished from the glands of the same name above referred to in the turbellarians. In *Rhabdocoelida*, however, there are, as already mentioned, two sorts of salivary glands; and in this case those that open between the pharynx and the intestine are perhaps analogous to or at any rate a forerunner of the salivary glands of the ectoparasitic Trematodes. In *Distomum Westermanni* (Kerbert) and *Dist. palliatum* (Looss), there are also true salivary glands opening into the oesophagus. As to the function of these glands I am not in a position to make any assertion; but some light will perhaps be thrown on the question after we have considered the characters of the intestinal epithelium.

We have already seen that the intestines may be distinguished into two types according to the character of their epithelium. We shall begin with the first type, *viz.*, that in which the epithelium is discontinuous, and in which the cells contain numerous dark-brown or almost black granules. The chief question on which I shall venture to make a few remarks is about the nature of these pigment granules. On this point there are, so far as I know, two views. According to Taschenberg<sup>2)</sup> these pigment granules are the food-particles taken in by these cells from the cavity of the intestine; and in support of this view he cites his observation that these pigment granules are most

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1). Brandes—Die Familie der Holostomiden. Zoolog. Jahrbücher. Abtheil. f. Syst. Geo. u. Biologie. Bd. 5, 1891. p. 553-561.

2). Taschenberg—Weitere Beiträge zur Kenntniss ectoparasit. mariner Trematoden, 1879. p. 11-12.

abundant when the intestine contains numerous fat-globules, and *vice versa*, which would not be the case were these granules emptied into the intestinal cavity. The other view regards these granules as zymogenic in nature. This view is probably represented by Zeller<sup>1)</sup>, who says, "Die Zellen lösen sich mit der Zeit ab und zerfallen. Die abgängigen werden durch junge ersetzt, welche zwischen jenen sich bilden. Offenbar stehen diese Zellen in ganz bestimmter Beziehung zur Verdauung." A third view is possible, according to which these pigment granules are the indigestible remnants of the food taken in by the cells, whether the food be in the form of granules or whether it be entirely fluid. In my paper on *Diplozoon*<sup>2)</sup>, I followed Tasehenberg; but further observations and especially a careful comparison of these pigment granules with the granules found in the epithelial cells of *Monocotyle* have convinced me that the two are not of the same nature. It is, moreover, difficult to understand by what means digestion is carried on in those forms which have the intestine of the first type; for in these, salivary glands, or any other glands which may be supposed to have a digestive function, are totally wanting. The unicellular glands around the oesophagus described by Zeller in *Polystomum integerrimum* are, I believe, analogous to the pharyngeal glands of *Tristomum*; at least they open at a similar place. Again, in some specimens of *Ouchocotyle* killed with hot sublimate shortly after being detached from the host, I have often observed, in sections, the pigment granules in question in the cavity of the intestine, sometimes in groups and imbedded together in a weakly stained mass. In these cases it is difficult to conceive any external force by which the intestinal cells might have been torn away from the tunica propria. It is

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1). Zeller—Weiterer Beitrag z. Kenntn. d. Polystomen. Zeitschr. f. wiss. Zoolog. Bd. 27 1876, p. 241.

2). This Journal, Vol. IV, Pt. I. p. 174.



therefore perhaps allowable to believe that the pigment granules are normally thrown out into the intestine and there furnish the necessary means for the digestion of food. On the other hand, this observation may also be advanced in favour of the third view, according to which the pigment granules would be finally thrown away by way of the mouth. Zeller indeed says that the intestinal cells detach themselves from the wall ; and in this case it is difficult to understand the total absence of any phenomena of division among them. According to my own observation, however, only the pigment granules seem to be thrown out, surrounded by a scanty mass of protoplasm, while the cells themselves in all probability remain collapsed in their former positions, and again resume their activity after the lapse of a certain interval. According to the second view, the smaller cells observed in *Onchocotyle* with a well staining protoplasm and containing fewer granules of smaller size are to be regarded as those which have not yet arrived at the height of secretory activity ; while according to the third view they are to be regarded as those in which much refuse matter has not yet accumulated.

If digestion be regarded as taking place in the cavity of the intestine by means of the pigment granules acting as a ferment, then its product could pass into the tissue only by osmosis and filtration. If, on the other hand, the pigment granules be regarded, according to the third view, as the indigestible remnants of the food taken in by the cells, then digestion has to be regarded as taking place intracellularly ; but in this case the essential nature of the process would remain unknown ; and it remains, moreover, to ask in what way the digested food is passed on into the fluid which fills the mesenchyma—a fluid which furnishes in all probability the necessary nutriment to the various organs. I feel myself therefore obliged to leave the nature of the pigment granules undetermined.

In the intestine of the second type, the epithelial cells are, as already stated, all alike, and do not contain pigment granules. In *Tristomum* and *Calicotyle*, they stain but slightly, and have seemed in some cases to be more or less vacuolated. In *Monocotyle Ijima*e, on the other hand, they contain numerous, deeply staining granules which are to all intents and purposes exactly similar to the granules found in the cavity of the intestine of the same worm. I therefore believe them to be the products of (partial ?) digestion taken in by the epithelial cells.

But by means of what is this (partial ?) digestion carried on ? It has already been mentioned that the cells are all alike in appearance, and none of them present any glandular appearance. In some polyclads (*Planoceridae*), Lang<sup>1)</sup> has described two forms of cells in the intestinal epithelium : those of the first form were elongated and cylindrical, and usually contained large, homogeneous, refractive granules which stained but slightly and looked like fat-globules ; those of the second form were more or less club-shaped, with the thickened end turned towards the lumen of the intestine, and these contained, besides an elongated nucleus, numerous granules which were very deeply stained, and which distinguished themselves from those of the other form of cells by their much smaller size and a regularly spherical shape. The latter cells the above named author regards as secretory cells, and the granules as the product of secretion. In *Distomum Westermanni*, again, Kerbert<sup>2)</sup> found, besides the ordinary intestinal cells, "kolbenförmige Gebilde" similar to those of the turbellarians, which however he holds as nothing else than ordinary epithelial cells whose shapes have been changed by the ingestion of food. In *Sphy-*

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1). Lang—*l. c.* p. 141.

2). Kerbert—Beitrag zur Kenntniss der Trematoden. Archiv. f. mik. Anatomie. Bd. 19, 1881. p. 552.

*ranura*, Wright and Macallum<sup>1)</sup> hold that the greater part of the digestive process is effected by the fluid content of the intestine, which they think is of an acid reaction. This they infer from their observation that the swallowed epithelial cells of the host have the form of their nuclear chromatin preserved for a long time, which would not be the case were the intestinal fluid of an alkaline reaction. These writers seem to hold also that the secretion of the digestive enzyme and the ingestion of food granules—which they concede to take place to some limited extent—are effected by one and the same cells. Now, remembering that even so low in the scale of life as in *Hydra*<sup>2)</sup> the cells of the endoderm are differentiated into two kinds, the secretory and the absorptive, it would seem to many very improbable that these two processes should be carried on in the Trematodes by one and the same cells. Confining our attention to the ectoparasitic Trematodes, we see that in all those forms which have the intestine of the first type, *viz.*, that in which the epithelium is discontinuous, and the cells contain numerous pigment granules, the salivary glands are totally absent; while in those which have the intestine of the other type they are well developed. Considering this fact in conjunction with the view that the pigment granules of the intestinal cells of the first type are of a zymogenic nature, the thought suggests itself whether the pigment cells of the intestine and the salivary glands are not, in the ectoparasitic Trematodes, vicarious in their functions; and there seems to be no fact, at least for the time being, that is obnoxious to this assumption. In the *Planocercidae* the so-called salivary glands secrete only a sticky fluid, hence the necessity of secretory cells in the intestine. In the *Rhabdocerlida*, in some of which the salivary glands are, as already

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1). Wright and Macallum—*Sphyrnanura Osleri*. Journ. of Morphology, Vol. I, 1887, pp. 33, 35.

2). Cf. Greenwood—On Digestion in *Hydra*; with Some Observations on the Structure of the Endoderm (Journ. of Physiology, vol. IX, 1883, p. 317—344) and Nussbaum—Ueber die Teilbarkeit der lebendigen Materie (Arch. f. mik. Anat., Bd. 29, 1887, p. 265-366).

mentioned, divided into two groups, digestion is, according to Graff,<sup>1)</sup> exclusively carried on intracellularly. It is allowable, however, to suspect whether the secretory cells have not been overlooked in some forms, especially in those in which the salivary glands form only a single group opening on the surface of the pharynx. One may, again, regard the "kolbenförmige Gebilde" of *Distomum Westermanni* as secretory cells, and bring them forward in opposition to our assumption; since in this species the true salivary glands are present. But if our assumption be true, there would be a time in the phylogeny of the glands in question when both the true salivary glands and the secretory cells of the intestine would discharge their functions side by side. It may also be said in the way of objection to our assumption, that food granules are observed in the intestinal cells, and that this makes it very probable that these cells have the power of digesting them. But it seems to me that these granules are not the product of a simple disintegration of the swallowed food, but that they have been produced by the action of a certain (partially ?) digestive fluid; and moreover it may be suspected whether these granules are not, as suggested by Greenwood<sup>2)</sup>, formed secondarily in the cells, and whether they are not taken in primarily in the fluid form.

### 7. The Excretory System.

The excretory system is constructed on the same fundamental plan in all the genera treated of in this paper, and presents only some slight deviations in different genera. In all of them, there are two main vessels on each side of the body, which are directly continuous with each other at the posterior end. They run, roughly speaking, on the ventral side of the intestine between it and the ventral nerve;

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1). Graff—Monographie, p. 96.

2). Greenwood—*l. c.* p. 323.

but as their course is always more or less winding, they are not seen in cross-sections exactly between the intestine and the ventral nerve, but are often situated more on one side, right or left, as the case may be. One of the two main vessels, the larger one, opens to the exterior mostly with an extremely small pore in the anterior part of the body on the dorsal side, close to the lateral border. This is also the case in *Onchocotyle*, the paired terminal sacs described by Taschenberg<sup>1)</sup> being, as already stated, nothing else than the suckers. In *Microcotyle*, I have not been able to observe the excretory vessels in specimens mounted *in toto*, and therefore have not drawn them in the figures; but I could always recognize the two main vessels in serial cross-sections. In this genus, the excretory openings are situated nearly on the same level with the genital opening: in *M. elegans* it is 5 sections (each = 10  $\mu$ ), and in *M. caudata* 10 sections in front of the genital opening; while in *M. sebastis* it opens on the same level with it. Lorenz speaks of a small papilla on which the excretory vessel opens; but I have not observed any in my sections. In this genus, there is no distinct terminal sac, the vessel presenting just a perceptible enlargement before it opens to the exterior. In *Diclidophora* also, the excretory openings are nearly on the same level with the common genital opening: *e. g.* in *Diclid. sessilis* it is about 7 sections (each = 10  $\mu$ ) behind it; but in this genus there is a tolerably large, egg-shaped terminal sac (Pl. X, fig. 5), which opens directly to the exterior. In *Acine*, *Onchocotyle*, and *Hexacotyle*, the excretory openings are at some distance in front of the common genital opening, and the two main vessels present each only a slight enlargement before opening to the exterior. In *Monocotyle*, there is a large terminal sac of an ellipsoidal form, which communicates with the exterior by means of a short canal proceeding from its dorso-lateral border a little before the middle

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1). Taschenberg—Weitere Beiträge, p. 13.

of its length, and opening to the exterior on the dorsal surface of the body (Pl. XVII, fig. 2 & Pl. XVIII, fig. 5). In *Tristomum*, finally, the larger of the two main vessels of the excretory system communicates, in the anterior part of the body a little behind the anterior sucker, with a large but short vessel, which proceeds thence anteriorly and towards the dorsal surface of the body, on which it opens a little behind the sucker, almost midway between the lateral border of the body and the internal ventral nerve (Pl. XX, fig. 1). This terminal excretory vessel is sometimes much swollen so as to deserve the name of a terminal vesicle.

In *Microcotyle* and *Onchocotyle*, the two vessels run roughly parallel to the lateral borders of the body, and remain quite distinct from each other throughout their entire lengths, the smaller vessel proceeding past the excretory opening towards the anterior part of the body, and there dividing into numerous smaller vessels. This is also the case in *Hexacotyle*; but in this genus, the vessels, on reaching the posterior suckers, turn towards the median line of the body, keeping close to them, and passing between the innermost small sucker and the next one, turn again towards the lateral border of the body, and become continuous with each other directly behind the outermost sucker (Pl. XIII, fig. 4). In *Dididophora*, the main vessels of each side become continuous with each other at the posterior end by a cross commissure at about the level of the second pair of suckers (Pl. X, fig. 5). In *Axine* again, the main vessels of one side of the body are very much longer, in accordance with the asymmetrical form of the body; and the vessels of the two sides approach very near each other at the posterior extremity of the body, and are there united by a very short transverse vessel (Pl. VII, fig. 1). The connection of the vessels of the two sides are also effected in a similar way in *Monocotyle* near the posterior extremity of the intestine. Close to the point of connection,

a vessel is given off on each side to the posterior part of the body and the sucker (Pl. XVII, fig. 2). Finally in *Tristomum*, the two main vessels are much more separated from each other than in the other genera; and the larger vessel runs about midway between the internal and the external ventral nerve, and becomes continuous with the smaller vessel a short distance in front of the posterior sucker. Anteriorly the larger vessel becomes continuous at the base of the terminal vessel (vesicle) already described with another vessel, which proceeds anteriorly and unites with an exactly similar vessel of the other side just in front of the pharynx on the dorsal side of the brain. The median vessel thus constituted proceeds for a short distance forwards, and then divides right and left into two branches, the ramifications of which supply the anterior suckers and the anterior parts of the body proper.

From the two main excretory vessels above described, numerous branches are given off at various points apparently without any regularity. These branches divide again and again, and the smaller branches anastomose variously with each other and with those coming from the opposite side of the body. I have not been able to observe the terminal funnels of the excretory capillaries in any of the marine species I have hitherto studied. It should however be mentioned to avoid misunderstanding that I have not as yet had as much opportunity for observing these funnels as I could wish; and considering their wide distribution among the Plathelminthes, it is scarcely to be doubted that they would be found also in all ectoparasitic Trematodes. In *Tristomum sinuatum*, however, I have observed the excretory capillaries form a close network just inside the muscular layer of the body. So far as I have observed, the transition from the capillaries to the ordinary excretory vessels does not seem to be so sudden as in those forms whose excretory systems have been so

minutely described by Pintner<sup>1)</sup> and Fraipont.<sup>2)</sup>

The wall of the excretory vessels, the larger as well as the smaller, is constituted alike in all the species studied by me ; and consists of a structureless, refractive membrane which is, in most species, very thin, but on which a double contour can be distinctly recognized. In *Monocotyle*, the wall is much thicker, as may be seen in fig. 5, Pl. XVIII. The membrane stains more or less with haematoxylin in most species, and this is especially the case in *Monocotyle*. The wall of the terminal sac is exactly of the same appearance as that of the vessels. In some sections of *Tristomum sinuatum*, I have observed an elongated nucleus lying closely appressed to the wall of the excretory capillaries ; but owing to the extreme rarity of such observations, I could not decide whether it belonged to the wall or merely to the mesenchyma.

The calibres of the vessels are observed to vary a great deal according to the various degrees of distention in which they are held by the contained fluid ; and it is a necessary consequence of this that the thickness of the membrane that constitutes the wall should vary accordingly.

In some sections, I have observed in the cavity of the excretory vessels a flaky substance lightly stained by haematoxylin ; but this was rather seldom, and in most cases the cavity was wholly empty and clear.

In my paper on *Diplozoon*<sup>3)</sup> I have specified three alternative ways in which the wall of the excretory vessels can be supposed to have arisen, viz., either (1) it arose by a simple transformation of the protoplasmic wall such as we find in the turbellarians, or (2) it had been

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1). Pintner—Untersuch. ü. d. Bau des Bandwurmkörpers. Wiener Arbeiten. Bd. III, 1880.

2). Fraipont—Recherches sur l'appareil excréteur des Trématodes et des Cestoïdes. Archives d. Biologie. T. I, 1880. p. 415.

3). *l. c.* p. 176.



produced by a distinct external epithelium such as has been described by Pintner in the Cestodes, which then underwent degeneration, or finally (3) it may be only the remnant of the walls of the original cells whose internal part has been absorbed and which thus gave rise to the cavity of the excretory vessel. As I have pointed out in my paper just referred to, in the extreme case, *viz.*, where the cells are arranged in a single row, the last view reduces itself to the first; and in this case the term "intracellular" has been used by most writers on the subject. Quite recently Haswell<sup>1)</sup> has extended the application of this term to the terminal sac of the excretory system of *Temnocephala*, so that according to this author the main canals as well as the terminal vesicles are wholly *intracellular*. The ground on which these writers regard the cavity of the excretory vessels as intracellular has been clearly stated by one of them—the one, as far as I know, who used the term for the first time—; and to avoid any misinterpretation I shall quote his own words. He says,<sup>2)</sup> "In ziemlich grossen Abständen verdickt sich die Wand der grossen Canäle einseitig und enthält einen deutlichen, ovalen Kern. An diesen verdickten Stellen inserirt sich stets je ein Büschel viel längerer Cilien. Die Kerne sind so weit voneinander entfernt, dass auf eine längere Strecke je eine einzige Zelle die Wand der grossen Canäle bildet; mit anderen Worten, diese Canäle sind intracellulär, sie stellen, durchbohrte Zellen dar." From this it is I think very clear that the excretory vessels are called intracellular only because the nuclei are never found more than one in the same section, but separated from one another by wide intervals. It may be doubted, however, whether this alone justifies the use of the term, and whether there is not another

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1). Haswell—On the Excretory System of *Temnocephala*. Zool. Anz., XV. Jahrg., 1892, p. 149-151.

2). Lang—Die Polycladen des Golfes von Neapel, p. 165-166. This writer also applies the term "intracellular" to the vas efferens of some polyclads.

way of interpretation. Pintner<sup>1)</sup> has described a well developed epithelium on the main vessels of the excretory system. Hence I think it is more in accordance with the procedure elsewhere general, to regard the excretory vessels not as intracellular but as bounded by a true epithelium, which however, consists of only a small number of cells, so that the single cells have been greatly flattened and have assumed the form of a tube by the union of its opposite margins. In this case, the cavity of the vessel would be as truly outside the cell as any other intercellular spaces. It is true indeed, that according to Schwarze<sup>2)</sup> the terminal excretory vessels of the distomes are formed by the absorption of the axial part of an originally solid string of cells. But even taking this statement as it stands—and without suspecting whether it may not be formed by a simple rearrangement of the cells as is stated by Looss<sup>3)</sup> to be the case in the genital ducts,—it is not necessary to suppose that exactly the same process takes place in the smaller vessels as in the terminal vesicle; and therefore the view is perfectly allowable that where the cells are arranged only in a single row, each one assumes, to speak on supposition, a crescent shape at first and then closes into a tube by the union of the opposite margins. Such tubes, open and placed end to end would form a vessel such as is found in the turbellarians. There is another objection to the word “intracellular”; and that is the presence of cilia on the internal surface of the wall of the vessels. So far as our experience goes, there is no case in which cilia are found growing *within* the cells, but only on the external surface.

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1). Pintner—Untersuch. ü. d. Bau des Bandwurmkörpers. Wiener Arbeiten. Bd. 3, 1880. p. 21.

2). Schwarze—Die postembryon. Entwickl. der Trematoden. Zeitschr. f. wiss. Zool. Bd. 42, 1886. p. 58.

3). Looss—Ist der Laurer'sche Kanal der Trematoden eine Vagina? Centrallbl. f. Bakteriöl. u. Parasitenk. Bd. XIII, 1893. p. 809 (Nr. 25).

The foregoing discussion may have seemed needlessly long to some readers; but it has appeared necessary to me, as one writer must have been misled by the term "intracellular," and thus been prevented from seeing the real significance of the structure he was studying. I refer to Otto Bürger. According to this writer<sup>1)</sup> "die Kanäle des Nephridialapparates der Nemertinen sind mit einem Flimmerepithel ausgestattet und enden mit hohlen blinden Kölbchen, die gleichfalls ein einschichtiges vielzelliges Epithel auskleidet. In jedem Kölbchen, angeheftet am blinden verdickten Ende, schwingt eine Wimperflamme in das Lumen des Kölbchens hinein." And after referring to the works of Lang and Pintner he proceeds,<sup>2)</sup> "Man ersieht aus dem Angeführten, dass ein genaueres Studium der Nephridien der Nemertinen nicht dazu führen kann, sie als typischen Exkretionsapparat der Plathelminthen hinzustellen. Sehr schwer wiegt meines Erachtens der Mangel einer Schlusszelle. Sie wird bei den Nemertinen ersetzt durch den Wimperkolben.....Ich bezweifle nicht dass beiderlei Nephridien genetisch grundverschiedene Bildungen sind.....Die Entwicklung der intracellulären Nephridienkanäle hatte jenen eigenthümlichen Endapparat in Gestalt der Trichterzelle in Gefolge, eben so (oder besser gesagt aus demselben Grunde) wie mit der Entwicklung der Nephridienkanäle der Nemertinen, die von Anfang an epithelial ungrenzte Hohlräume darstellen werden, die Entwicklung der Wimperkolben—es folgt das Eine aus dem Anderen—Hand in Hand gehen wird." It is somewhat surprising how near the mark the writer comes but seems to miss just on the point of hitting it. And from the above quotations, it will be clear that the word "intracellulär" has had a not inconsiderable part in the matter. The writer also lays weight on the difference of the epithelium

1). Bürger—Die Enden des exkretorischen Apparates bei den Nemertinen. Zeitschr. f. wiss. Zool. Bd. 53, 1892, p. 330 *et seq.*

2). *I. c.* p. 331 *et infra.*

described by Pintner, which is situated outside the cuticular membrane. But to me it seems that the mere presence of a cuticle is morphologically a quite unimportant matter, so that the "Aussen-epithel" of Pintner is as truly an epithelium as that of the excretory canals of the Nemertinei, just as the cells that produce the chitinous wall of the trachea of insects are as truly of an epithelial nature as any others that do not secrete chitin. Then as to the difference of the terminal "Kolben" of the Nemertinei from the terminal excretory cells of other flat-worms, it seems to me that this is also of quite a secondary significance; that an organ consists of a single cell does not afford, it seems to me, any more reason against its homology with a multicellular organ than the fact that an organ consists of five cells is any ground against its being homologous with another consisting of six cells. If, on the other hand, we do not take into account the number of cells, there is a striking similarity between the terminal excretory organs of the Nemertinei and other Plathelminthes. I therefore believe that the excretory systems of the Plathelminthes, the Nemertinei inclusive, have all been derived from the same primitive form, in other words, that they are homophylous.

To recapitulate the above discussion, it is my opinion that the term "intracellular" is quite inappropriate to the excretory system of the Trematodes and the Turbellaria, as it gives occasion to much misapprehension and prevents the true understanding of the exact state of the matter. It is also my opinion that the excretory systems of the Nemertinei and the other Plathelminthes are phylogenetically of the same origin, the number of cells that compose the various parts of the system being of quite secondary importance in discussing its phylogeny.<sup>1)</sup>

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1). Whitman, from a totally different point of view, comes to the same conclusion. He says, "The nephrostome is a nephrostome all the same whether it consists of one cell, two cells,

8. *The Nervous System.*

The *brain* is situated in the anterior part of the body. In *Tristomum*, *Calicotylo*, *Epibolella*, and *Monocotyle*, it is in front of the pharynx; in *Microcotyle*, *Octocotyle*, *Dictidophora*, *Hexacotyle*, and *Arcine*, it is behind, while in *Ouchocotyle* it is just over, the same organ. It is always situated on the dorsal side of the body, and is a somewhat cylindrical nervous mass crossing the median line. From it is given off both forwards and backwards a certain number of nerves. In all the species that I have examined, two pairs of nerves proceed posteriorly from the two lateral ends of the brain, which may be distinguished as the *external*<sup>1)</sup> and the *internal lateral nerves*. The internal lateral nerves are by far larger than the external, and proceed in most species along the main trunks of the intestine towards the posterior end of the body. In *Tristomum*, it is about midway between the lateral border of the body and the median line, and runs almost parallel to the former. In this genus the two lateral nerves of each side unite with each other on entering the posterior sucker, and the single nerve thus formed immediately divides into a certain number of smaller branches, which supply the various parts of the sucker. Thus, a nerve is given off towards the anterior part, which runs concentrically with the circumference of the sucker, and after giving off at intervals some lateral branches, unites at last with its fellow of the opposite side; so that this nerve

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or many cells. Its form and function are independent of the number of component cells. Cells multiply, but the organ remains the same throughout" ("The Inadequacy of the Cell-theory of Development" in *Journal of Morphology*, vol. VIII, 1893, p. 615); thus extending the homology not only to the Nemertine but also to the annelids. Monticelli, on the other hand, in his "Primo contributo di osservazioni sui Distomidi," which I received after the above had been written down, homologises the terminal funnel of Plathelminthes with the head-kidney of annelids (*cf. l. c.* p. 45 *et infra*). Schuberg is reported to have arrived at a similar conclusion concerning the nature of the wall of the excretory capillaries.

1). In my paper on *Diplozoon* I have called this pair the ventro-lateral nerves, but the terms above mentioned are better as being of wider application.

describes a circle which is incomplete only at the hinder part. A second nerve is given off towards the hinder part of the sucker; this gives off at a short distance from its origin a small branch, and after this, it takes a somewhat similar course in the hinder part to that pursued by the first nerve in the anterior, but remains throughout separate from its fellow of the opposite side. A third nerve is given off towards the lateral part of the sucker; but this soon proceeds forwards, and runs almost concentrically with the first nerve, but outside it near the margin of the sucker. This nerve could be followed only for a comparatively short distance. These three nerves all take their origin at the same point, and are represented in fig. 1, Pl. XX.

In *Diclidophora* (Pl. X, fig. 5) and *Monocotyle* (Pl. XVII, fig. 1), the external lateral nerve could be traced along the ventro-lateral border of the body almost up to the point of union with the internal lateral nerve; but in all the other genera that have come under my observation I could follow it only for a comparatively short distance; and in these it became gradually so small and its tissue so imperfectly differentiated from the surrounding mesenchyma that I could not be sure whether I had the section of the nerve before me or not. The internal lateral nerves, on the contrary, could always be distinctly followed up to the region of the suckers; and in *Onchocotyle*, they become continuous with each other and form a loop at about the level of the second pair of suckers, on the ventral side of the intestine (Pl. XV, fig. 2).

In *Tristomum*, a pair of dorsal nerves has been described by some writers, and I have myself observed it in *Onchocotyle*; but in all the other genera, I could not demonstrate it with any satisfaction to myself.

The four posterior nerves are united with each other at regular

intervals by numerous commissures, which all lie in the same straight line (Pl. XXI, fig. 1). At a short distance from the brain, a branch is given off from the internal lateral nerve towards the median line; this curves inwards and supplies the pharynx. Besides the regular commissural nerves Lang<sup>1)</sup> has described others which take more or less irregular courses. I have observed similar nerves; but they seem to be of quite irregular occurrence, and to run in various directions, but more or less parallel to the diagonals of the rectangles formed by the lateral nerves and their commissures. I have represented such a nerve in the anterior part of the body in fig. 1, Pl. XX. Again, in *Tristomum* in the posterior part of the body, just before the suckers, the commissures of the two internal lateral nerves give off branches which anastomose variously with one another as well as with the neighbouring commissures, and form a network in this region (Pl. XX, fig. 1). The commissural nerves are continued towards the lateral parts of the body and there divide into numerous branches. In the posterior part of the body there are, besides the direct continuations of the commissural nerves, others which branch off from these and proceed towards the lateral part of the body; so that the transverse nerves in the lateral parts are more numerous than the regular commissures.

In *Acine* (Pl. VII, fig. 1), the internal lateral nerve of one side is much longer than its fellow of the other side, and gives off a large nerve at about the middle of the seemingly posterior border of the body, which then proceeds along it close to the suckers in a diametrically opposite direction from the main nerve. This branch is to be regarded as a special development of one of the commissural nerves which are no doubt present in this genus also. The nervous system also

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1). Lang—Untersuch. z. vergleich. Anatomie u. Histologie des Nervensystems der Plathelminthen. II. Mitheil. a. d. zoolog. Station zu Neapel, Bd. 2, 1881. p. 35.

is moulded in accordance with the general asymmetry of the body.

From the front of brain two pairs of nerves are given off (Pl. XX, fig. 1), the inner of which proceeds towards the corners of the anterior border, its branches supplying mainly that part of the body which lies between the anterior suckers. The outer pair is connected with the posterior nerves by a commissure, which arises at the common base of the two posterior nerves, and curving a little outwards, unites with the external anterior nerve at a short distance from its origin. The external pair mainly supplies the anterior suckers.

The above description of the commissures and the anterior nerves is based mainly upon observations on *Tristomum*. In the other genera, also, the commissures are present and can under favourable circumstances be demonstrated in sections; but I have not had enough opportunity to examine fresh specimens, and therefore have not been able to obtain a general view of the arrangement of the commissures and their relations to the main nerves.

I shall now proceed to the histology of the nervous system, and shall begin with the brain.

In cross-sections of the body, the brain is seen to be a band-shaped body arching over the alimentary canal (oesophagus, pharynx, or mouth-cavity, as the case may be), and in many species is entirely free from cells. The greater part of its substance consists of connective tissue, and, being consequently slightly stained, is very conspicuous in cross-sections. In some species, however, it contains besides the reticulated connective tissue a finely granular substance which stains more deeply than the former, but after all only weakly, as in *Microcotyle fusiformis* (Pl. IV, fig. 6) and *Diclidophora sessilis* (Pl. XI, figs. 1 and 2). In most species of *Microcotyle*, there are numerous, well staining, rounded nuclei containing one or a few nucleoli crowded around the brain (Pl. IV, fig. 6), while no



obviously ganglionic cells can not be observed; but in *Microcotyle sebastis* there are two pairs of large polygonal cells in the ventro-lateral portion of a cross-section passing through the anterior part of the brain, which are provided with very large, vesicular nuclei with a distinct membrane and containing each a single, large nucleolus and numerous, weakly stained granules (probably chromatin). The protoplasm is finely granular and has no external membrane, so that the cell-body becomes gradually fainter towards the periphery (Pl. IV, 5). In *Axine heterocerca* (Pl. VIII, fig. 2) also, there are some cells of this kind of various sizes in the same region of the body. In *Dictidophora sessilis* (Pl. XI, figs. 1 & 2) the brain itself is entirely free from cells of all sorts; but at the root of the posterior nerves, there are numerous cells of polygonal form with finely granular, well-staining protoplasm, and with a nucleus containing one or more nucleoli. These are undoubtedly nerve cells. Besides these, however, there are in this species two pairs of gigantic cells in that part of the body which corresponds to where the large cells already mentioned are found in *Microcotyle sebastis*. They are polygonal in form, and the large vesicular nucleus, which contains, besides a single large nucleolus, numerous small granules, is surrounded by a very finely granular, well-staining protoplasm which is totally destitute of an external membrane. Sometimes the protoplasm has seemed to be drawn out into a faint process, and fibres to be given out from the periphery of the nucleus (Pl. XI, fig. 1, left side). I have described similar cells in similar positions in *Diplozom*<sup>1)</sup>; and I have no doubt that they as well as those of *Microcotyle* and *Axine* are ganglionic cells.

In *Tristomum*, there are numerous ganglionic cells within the brain as well as in the main nerves. The greater number of them are

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1). *l. c.* p. 174, and fig. 25.

bipolar cells, but there are also among them multipolar cells (Pl. XXIV, fig. 5); and unlike what is seen in the other genera, the fibres proceeding from them can be very distinctly followed for a considerable distance. These fibres are direct continuations of the protoplasm of the cells, are destitute of any sheath, and run in the long direction of the brain, *i. e.*, at right angles to the long axis of the body. They stain quite deeply near the nucleus, but become fainter and fainter as we follow them away from the nucleus, until they finally, in their affinity for stains, become scarcely distinguishable from the fluid which fills the meshes of the connective tissue.

In the brain are imbedded the *eyes*, when such are present. Among the genera I have studied, these are present only in *Tristomum*, *Epibdella*, and *Monocotyle*, and are arranged in two pairs. In all the three genera just mentioned, their relative positions are such that an isosceles trapezoid is formed by connecting them. In *Tristomum* and *Epibdella*, the shorter of the two parallel sides of the trapezoid is situated anteriorly, while in *Monocotyle* the reverse is the case. I have carefully studied these eyes only in *Tristomum ocale*; and my results are somewhat different from those arrived at by Lang.<sup>1)</sup> This writer enumerates four elements of which a single eye is formed, *viz.*, (1) the pigment, (2) the lens, (3) the retina, and (4) the ocular muscle. According to my observation the last is no other than the dorso-ventral muscles of the body which traverse the brain close to the eyes, and it therefore seems to me morphologically more correct to call them by that name, although physiologically they take great part in the movements of the eyes, which are merely passive, the worm having no power to direct its eyes in any special direction. In the anterior eye (Pl. XXIV, fig. 3) the lens is an ellipsoidal,

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1). *l. c.* p. 41

homogeneous body capped on the dorsal side by a mass of black pigment granules. Immediately beside it there is a tolerably large ganglionic cell, the processes of which pass on to both the dorsal and ventral sides of the lens. In the posterior eye the place of the lens is taken by a large multipolar ganglionic cell also capped by a mass of pigment granules. The nucleus of this cell is very large and spherical in form; it stains more deeply than the protoplasm, and no definite structure can be observed within it except some faintly staining granules (Pl. XXIV, fig. 4).

In the above description I have adopted the name commonly used and have called the structures described eyes. Morphologically speaking they are certainly degenerated eyes; and have probably been derived from some such eyes as are found in the Turbellaria; but I do not think that they are functional. In the first place, the pigment granules are situated on the dorsal side and thus prevent the light from reaching the lens, since the dorsal side is the only direction from which light can come. In the second place, there is not always a distinct retina. In *Tristomum molae*, the species studied by Lang, the retina is said to be present; but in *Trist. ocula* there is none, since the ganglionic cells in the immediate vicinity of the lens already mentioned are not in such a position as to receive the light that has passed through the lens. If these "eyes" are really still useful to the animal, they may possibly be a temperature sense organ; and for this purpose their structure seems to answer well. For, the black pigment granules would easily absorb the dark heat-rays and cause some molecular change in the lens which they cap. This lens shows no cellular structure in the anterior eye, but in the posterior eye it is a veritable ganglionic cell, as has already been described. The temperature sense organ may be of use to the animal in warning it from wandering too near the extremities of the body of the host, where it

would be in danger of being swept away. But on this head nothing definite can be asserted. On the other hand, the comparatively perfect structure of the eye in *Tr. mola* may be due to the habit of this species. For, according to Lang<sup>1)</sup> and Monticelli<sup>2)</sup> this worm is met with very commonly on the surface of the body of *Orthogoriscus mola*, and is thus constantly exposed to light, which is not the case in *Tr. orale*.

In cross-sections the brain as well as the nerves show the reticulated appearance so universally described by students of the flat-worms. In the brain of *Tristomum*, the meshes are completely filled with nervous fibres, direct continuations of the processes of ganglionic cells (Pl. XXIII, fig. 4; Pl. XXIV, fig. 12; Pl. XXV, fig. 7; Pl. XXI, fig. 1); but in the nerves the fibres often do not quite fill up the meshes, but leave a clear space between themselves and the walls of the meshes. In *Tristomum*, as has already been mentioned, the fibres show less and less an affinity for stains as we recede from the nucleus, and finally they can scarcely be distinguished from the fluid that fills the meshes of the connective tissue; so that in this case the meshes of the nerves are seen in cross-section to be merely filled with a very weakly staining, slightly granular substance (Pl. XX, fig. 10). In *Declidophora* the nervous fibres are very slender, and in cross-sections are seen merely as minute dots (Pl. XI, fig. 1); while in nearly all other species the nervous fibres are very difficult to make out in cross-sections. The nerve itself, however, can be followed with certainty for the greater part of its course, but becomes indistinct in the posterior part of the body where, as already stated, the mesenchyma consists almost exclusively of reticulated connective tissue.

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1). Lang—*l. c.* p. 29.

2). Monticelli—Intorno ad alcuni elminti del Museo Zoologico della R. Università di Palermo. Naturalista Siciliano, An. XII, 1893. Estratto p. 5.

Doubt has been expressed by some writers whether the meshes of the nerves represent themselves the cross-sections of nervous fibres, or whether they are formed by the connective tissue with the fibres running within them. Poirier<sup>1)</sup>, for instance, on the ground of his observations on *Distomum* decides for the former view, and seems to believe the same to be the case also in the Turbellaria; but it will be, I believe, clear from my descriptions above that considerable variations must be allowed for in this respect, and that the results obtained from a single species or genus can not be applied *in toto* to others.

About the sense-organs on the surface of the body I have not been able to make any minute observation, and will only refer the reader to the interesting paper of Monticelli<sup>2)</sup> already mentioned.

### 9. *The Reproductive System.*

Since the general view of the reproductive organs can easily be obtained from the plates accompanying this paper, I shall at once proceed to the description of the constituent parts.

#### (a) *The Male Organs.*

TESTES—In all the species described in this paper there are more than one testis, and these are as a whole situated in the posterior part of the body behind the ovary. The only exceptions in this respect that I have observed are in *Diclidophora sessilis* (Pl. X, fig. 5), *Tristomum ovale* (Pl. XXIII, fig. 1), and the genus *Octocotyle* (Pl. IX, figs. 1 & 7). In the first of the species just mentioned, there are numerous testes, and these are situated not only in the posterior part

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1). Poirier—Contribution a l'histoire naturelle des Trématodes. Arch. d. Zool. expér. et générale. T. III, 1885, p. 603.

2). Monticelli—Di alcuni organi di tatto nei Tristomidi. Estratto dal Boll. della Soc. di Naturalisti in Napoli. Ser. 1, vol. 5, 1891, fasc. 2.

of the body but also in the anterior part, extending forwards almost as far as the brain ; in the second species also, the numerous testes extend forwards almost up to the anterior suckers on both sides of the ovary ; while in both species of *Octocotyle* described in this paper the anterior testes are arranged in a single row on the left side of the ovary, while the posterior ones are arranged in two irregular rows. In some other species also, as in *Onchocotyle* and most species of *Tristomum*, the foremost testes more or less overlap or surround the ovary ; but in the majority of species the testes are situated wholly behind the ovary. In most species again, they occupy the median portion of the body between the main trunks of the intestine, but in some species of *Tristomum* (*Tr. orale* and *Tr. Nozawai*) they stretch more or less into the lateral part outside the intestinal trunks (Pl. XXIII, fig. 1 ; Pl. XXV, fig. 1). In *Epibolella* there is only a single pair of testes of an irregularly ellipsoidal shape ; while in *Monocotyle* the testes are three in number, of which two are situated anteriorly and in a pair, and the remaining one posteriorly, with its anterior end more or less wedged in between the former. In all the other species the testes are very numerous, and are either rounded or more or less polygonal in form according as they are more or less pressed against one another. Sometimes also they are lobed, as in *Tristomum orale* (Pl. XXIII, fig. 1).

In most species the area occupied by the testes is entirely free from all other organs, and the testes are situated midway between the dorsal and the ventral side of the body. In *Tristomum orale*, however, the vitellarium, which in other species is confined to the lateral parts of the body, extends into the central portion ; and the testes are here situated quite on the ventral side, immediately inside the muscular layer, leaving the whole dorsal side for the vitellarium (Pl. XXIII, fig. 7).

Each testis is separated from its neighbours by a more or less thin layer of mesenchyma, which in this region assumes the character of reticulated, fibrous connective tissue (Pl. V, fig. 7; Pl. XI, fig. 3; Pl. XXIII, fig. 7; Pl. XXIV, fig. 2); and is usually destitute of any distinct epithelium. The testes are also traversed by the dorso-ventral muscular fibres; but the greater part of these pass between them through the mesenchymatous septa just mentioned. The contents of the testes consist of sperm cells in various stages of development, scattered without any regularity. In some species, as in *Diclidophora sessilis* (Pl. XI, fig. 5), I have often observed cells with large nucleus arranged in a single layer on the wall of the testis; but these seemed not to form a permanent epithelium. For, they were only loosely apposed to the mesenchyma, and in many testes, especially in those in which the greater part of the sperm cells had finished their development, they were wholly absent. A general view of the contents of the testes may be obtained from fig. 7, Pl. V, figs. 3 & 5, Pl. XI, fig. 7, Pl. XXIII, and fig. 2, Pl. XXIV. The most conspicuous elements besides the already developed spermatozoa are the groups of large nuclei containing a certain number (how many I have not been able to make out with satisfaction) of chromatin granules, the interspaces of which stain uniformly but far more weakly with haematoxylin, and the cells of large dimensions usually more or less of a spherical form, with a single, long thread of chromatin forming an irregular skein, or with numerous, more or less lozenge-shaped pieces of chromatin. The large nuclei just mentioned were usually surrounded by such a scanty layer of protoplasm as almost to look naked. Besides these there are also groups of much smaller nuclei imbedded together in a uniform mass of very finely granular protoplasm, which sometimes showed traces of separation corresponding to each nucleus.

The various elements above characterised are obviously stages in

the development of spermatozoa from the mother-cells ; and a glance at them will convince one that spermatogenesis must be effected in this group in a manner quite different from what we are wont to see in others. I have endeavoured to trace the various stages of spermatogenesis, and although I have not come out perfectly clear in every point of detail, still I believe I can communicate the result as being in the main correct. I have represented the various stages in fig. 3, Pl. VI, as found in *Microcotyle caudata*. The various zones that have been described by recent writers in the genital glands can not be distinguished in the testes of the ectoparasitic Trematodes ; on the contrary, the sperm mother-cells as well as the spermatozoa in various stages of development are, as already stated, mingled pell-mell. The youngest stage is probably that of the small nuclei already referred to as forming a group, each having a finely granular cytoplasm of its own (Pl. VI, fig. 3, *a*) and containing a small number (4 or 5) of chromatin granules. These nuclei grow larger and larger, and the chromatin granules increase in number and also more or less in size ; the cytoplasm, however, seems to remain almost constant, and in the stages represented in *b* and *c* it forms an inconspicuous thin layer around each nucleus. The individual nuclei become more and more detached from one another ; but I have sometimes observed them in these stages still kept together by a common mass of protoplasm (*d*). The nuclei still grow and grow, and the chromatin granules increase considerably in number (*e*) ; and although I have not been able to observe the intermediate stage, these granules must come either to form a reticulum and then a single thread, or passing over the reticulum stage form directly the single thread. The stage which I take to be the next is represented in *f*. Here the chromatin forms a single thread coiled so as to form numerous loops, and, so far as I have observed, having no end ; the nuclear membrane has also disappeared



and the thread lies in a very finely granular, weakly staining substance. Then this thread splits into numerous shorter pieces (*g*), which gradually separate more and more from each other, and finally occupy the periphery of the common mass in which they lie imbedded (*h, i*). At this stage each piece of chromatin has assumed a lozenge shape, and become intersected by small clear spaces, effecting a partial division of it into several parts. It contracts more and more and finally becomes a veritable nucleus (*k*) having a containing membrane with a few granules of chromatin (chromosomes) inside. The newly formed nuclei then repeat the very same changes above described, but how many times it is impossible to tell. The small lozenge-shaped chromatin pieces finally formed then begin to lengthen from one end (*m*), this time apparently without becoming a veritable nucleus such as is represented in *k*. The tail continues to lengthen more and more until only a small portion of the chromatin remains as the head, so that the ripe spermatozoon has the form of a long pin, formed head and tail throughout of chromatin (*n*); and all the spermatozoa derived from a single mother-cell of the last generation form a bundle, with the head imbedded in a common mass of finely granular protoplasm. It may be, however, that the protoplasm forms an exceedingly thin layer around the head as well as the tail. The spermatozoa seem finally to free themselves from the mass of protoplasm; for I have sometimes observed similar masses floating in the cavity of the testes (*o*). In *l* I have figured a stage which does not seem to come in well in the above series, and which I have observed only rarely. It may perhaps represent a stage immediately prior to the one represented in *k* and of exceedingly short duration. In it the small nuclei have each a cytoplasm of its own of prismatic shape, and are arranged on the surface of a central, spherical mass of protoplasm, which is wholly destitute of a nucleus.

The above account of spermatogenesis has been based on observations of *Microcotyle caudata*; but the process is essentially the same in all the genera treated of in this paper. It will be seen that it differs in many respects from the statements of other writers<sup>1)</sup> on the same subject; but the various stages observed seem to me to be capable of orderly arrangement only in the way indicated above. The process of spermatogenesis above described also differs considerably from that which takes place in *Diplozoon* (Pl. VI, fig. 4). In this the sperm mother-cell first divides by ordinary mitosis, then effects what has been termed reduction-division; and each daughter-cell thus formed develops into a spermatozoon, in which the chromosomes can still be distinctly seen. Finally the mode of division above described is so different from ordinary mitosis that I am not able to say what relation it bears to that. This and other obscure points indicated above I must leave to future investigations.

VAS DEFERENS—In *Tristomum* the vasa efferentia that proceed from the testes can in most cases be traced out; but this is possible only when they are made visible by being filled with spermatozoa, which stain very deeply with most colouring fluids. The vasa efferentia unite with one another and finally form a pair of large vasa efferentia, which again unite with each other in the median line of the body and form a single vas deferens. This is at first of small calibre, but becomes gradually larger and larger as it proceeds forwards on the left side of the ovary, and after undergoing numerous smaller windings, forms just in front of the ovary, a large loop, the closed end of which is directed towards the right side of the body, and in most species also more or less forwards (Pl. XX, fig. 1; Pl. XIII,

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1). Kerbert—Beitrag zur Kenntniss der Trematoden. Archiv f. mik. Anatomie, Bd. XIX, 1881, p. 559 *et infra*. Also Monticelli—(According to Braun's report in Centralblatt f. Bakteriologie u. Parasitenkunde, XIII. Bd., 1893, p. 180).

fig. 8 ; Pl. XXIV, figs. 6, 9, & 10 ; Pl. XXV, figs. 1, 3, 5, 8, & 9). It then proceeds either straight forwards or else a little to the left, making all the while numerous small but close convolutions ; and then turning more or less towards the right on the dorsal side of the penis, enters the latter close to its base. Here it forms a swelling, the *resicula seminalis*, and then again contracting to a very small canal and traversing the penis parallel to its central cavity, opens finally into this at some distance from its apex, in some species on the top of a papilla (Pl. XXII, fig. 4).<sup>1)</sup>

St.-Remy<sup>2)</sup> distinguishes in *Tristomum* three portions of the vas deferens, viz., (1) the single "canal séminal," (2) the "vésicule éjaculatrice" situated in the penis and receiving at one of its ends the narrow termination of the seminal canal and continued at the other into the (3) "canal éjaculateur," with which it communicates by a very short, narrow canal. It does not, however, seem to me necessary to distinguish these parts. As I have mentioned above, there are numerous constrictions in the course of the vas deferens ; but these are quite irregular, and can not, in my opinion, be taken as marking off distinct portions of the vas deferens from each other. It is, however, convenient to designate that portion of the vas deferens which lies within the penis the *ductus ejaculatorius*, although it should be remembered that in many species this is not the only portion that is concerned in ejecting the sperm fluid. In *Tristomum* and *Epibdella*, this portion is provided with circular muscular fibres (Pl. XXII, fig. 4 ; Pl. XXVI, fig. 7).

In *Epibdella* a short vas efferens proceeds from each testis ; but soon unites with its fellow and forms a single vas deferens. This

1). For minuter details see the description of species.

2). G. St.-Remy—Contribution à l'étude de l'appareil génital chez les Tristomiens. Archives de Biologie, T. XII, 1892, p. 5 *et infra*.

then runs forwards on the left side of the ovary, then towards the right, then again forwards, undergoing more or less windings on the way, and then towards the dorsal side of the penis, which it enters near its base and, traversing it longitudinally, finally opens into its cavity near or at its apex, just as in *Tristomum* (Pl. XXVI, figs. 1, 3, 4, & 6). During its course the vas deferens undergoes numerous constrictions and enlargements.

In *Microcotyle*, *Aeine*, *Diclidophora*, *Octocotyle*, *Hexacotyle*, *Calicotyle*, *Monocotyle*, and *Onchocotyle* I have not been able to observe the vasa efferentia. In these genera, the irregular cavities of the mesenchyma between the testes probably serve as such. The single vas deferens, however, can in all these genera be followed with certainty up to the testes. In *Calicotyle* the vas deferens proceeds forwards on the left side of the median portion of the body to near the pharynx, and then turns backwards and towards the right and continues its course into the penis. In most of the other genera above mentioned, the vas deferens takes its origin from the testes more on one side of the body, right or left according as the case may be, and undergoing numerous windings on its course forward, opens finally into the genital atrium. When the uterus and the vas deferens come to lie in the same sagittal plane, the latter is always situated on the dorsal side, and opens into the genital atrium also more dorsally than the former. In *Aeine* and *Microcotyle* the vas deferens proceeds forwards on the ventral side of the ovary (Pls. I, II, & VI).

The wall of the vas deferens consists in most species of a structureless, refractive membrane of varying thickness according to the species, and wholly destitute of nuclei; but in some species there is a more or less distinct protoplasmic layer separated from the mesenchyma by a basement membrane, and exhibiting at irregular distances, rounded or oval, well-stained nuclei, usually containing

each a single nucleolus, as in *Microcotyle chiri* (Pl. V, fig. 4), *M. sciencæ* (Pl. VI, fig. 2), and *Onchocotyle spinacis* (Pl. XVI, fig. 8). It seems to me therefore clear that the structureless membrane of the vas deferens of most species is to be regarded as the transformed product of the originally cellular epithelium ; and this becomes the more probable when we see that nuclei are present in some parts of the uterus but are wholly absent from others, as will be described later on. In those species in which the wall of the vas deferens consists only of a structureless membrane there is often a coarsely granular layer on the inner surface of the wall, which will be described presently in treating of the prostate gland. In most species the vas deferens is wholly destitute of any musculature ; but in some, as in *Microcotyle sciencæ* (Pl. VI, fig. 2) and *Hexacotyle* (Pl. XII, fig. 5), it is provided with a single layer of circular fibres.

In *Monocotyle* there is a peculiar organ around the vas deferens at a short distance from where this opens outwards (Pl. XVII, fig. 1 & Pl. XVIII, fig. 3, *bul. ej.*). It is spherical in shape, is hollow, and is traversed by the vas deferens. The wall of this organ is very thick, and consists of connective tissue fibres which are all arranged radially ; it is bounded both internally and externally by a structureless membrane ; but the external membrane is incomplete for a short space on the dorsal side, and here the substance of the wall is directly continuous with the surrounding mesenchyma,—the one passing gradually into the other—thus showing that both are of the same nature. On the surface of the internal limiting membrane there is a thin granular layer ; and just externally to the same membrane there is a layer of circular muscular fibres (Pl. XVIII, fig. 3, *bul. ej.*). The only use that I can attribute to this organ is to eject the sperm, and I shall therefore call it *bulbus ejaculatorius*. Around it there is a circular canal, the plane of which coincides with that of

the body (Pl. XVIII, fig. 3, *x*), and the wall of which consists of a thin refractive membrane, which bears at some points flattened nuclei. I have not observed any connection of this canal with the excretory vessel, and am at a loss to say what purpose it may serve.

In *Calicotyle* also there is a *bulbus ejaculatorius*. It is situated on the terminal portion of the vas deferens close to the penis, and is a somewhat dumb-bell shaped organ consisting of a compact connective tissue entirely separated from the surrounding mesenchyma by a membrane. The terminal rounded portions of the organ are hollow, and these hollows seem to communicate with the vas deferens by a very narrow canal, although on this point I am not able to make a positive statement owing to the scantiness of material (Pl. XIX, fig. 10). Considering, however, the close affinity of this genus to *Monocotyle*, I think I am justified in calling the organ in question the *bulbus ejaculatorius*.

An ejaculatory organ similar to that of *Monocotyle* has been described by St.-Remy<sup>1)</sup> in *Microbothrium*.

PENIS—In many species the terminal portion of the vas deferens is surrounded by a mass of connective tissue which presents a very different appearance from the general mesenchyma of the body, and is sometimes separated from it by a distinct membrane. This portion deserves, in my opinion, the name of penis, but it is clearly to be distinguished from the structure in connection with the genital atrium hereafter to be described. In many species two portions can again be distinguished in the penis, *viz.*, a more distal, chitinous portion and a more proximal portion consisting of ordinary connective tissue or of a modification of it. The latter portion I shall call the *connective-tissue penis* and the former the *chitinous penis*.

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1). G. St.-Remy—Étude de l'appareil génital, etc., p. 31.

The form and character of the penis are characteristic of the genera, and will therefore be treated separately for each.

*Diclidophora*—In this genus the penis is an ellipsoidal body situated right at the end of the vas deferens and bored by it through the centre. It bears a certain number (the number varies in different species) of chitinous hooks, together constituting the chitinous penis (Pl. X, figs. 2 & 3; Pl. XI, fig. 4). The substance of the penis consists of prismatic fibres arranged at right angles to its central cavity, *i.e.*, the vas deferens. These fibres are exactly like those which have been described in the suckers of *Microcotyle* and some other genera, both in their general appearance and in their reaction towards stains, and are separated from the surrounding mesenchyma by a distinct, structureless membrane. The chitinous hooks are arranged at regular intervals on the external face of the penis around the opening of the vas deferens, and although the proportions of the different parts vary in different species, they are constituted alike in all the species of the genus described in this paper. Each hook may be regarded as consisting of two portions, the basal and the distal. The distal portion consists of a slender, chitinous thread, and may be described as forming a loop, the free ends of which have fused together (Pl. X, figs. 7 & 10). This sits by the round end of the loop on the basal portion in such a way as to form an angle with it. The basal portion is hour-glass shaped when looked at from the front and is imbedded in the superficial part of the substance of the penis-bulb by its triangular end (Pl. X, figs. 7 & 10, *b*). In profile the basal portion looks somewhat triangular (Pl. XI, fig. 4).

*Octocotyle*—In this genus the connective-tissue penis consists of a median saucer-shaped body with two lateral bean-shaped bodies mounted on its edge (Pl. IX, figs. 5, 12, & 13). The median body is perforated through its centre by the vas deferens, and

on its external, concave face bears a number of recurved, chitinous spines, which together constitute the chitinous penis. Each of these hooks consists of a mound-shaped basal portion and a hollow, spinous distal portion. The substance of the penis bulbs has the same histological structure as that in *Dididophora*.

*Calicotyle*—In this genus the connective-tissue penis is a somewhat kidney-shaped body formed of fibrous tissue containing nuclei, separated however, from the surrounding mesenchyma by a distinct membrane, except at one place where the fibres of the surrounding mesenchyma are seen to be directly continuous with those of the penis (Pl. XIX, fig. 11). The penis has one end smaller than the other, and in its natural state, is placed so that its smaller end occupies a more dorsal position in the body than the other (Pl. XIX, figs. 7 & 11). Its smaller end is directly continued into the chitinous penis, which is an exceedingly long, hollow tube with obliquely cut end, and is twice bent on itself in such a way that the middle portion crosses the middle of the distal portion (Pl. XIX, fig. 10). As just side, its base is directly applied to the outer end of the connective-tissue penis (Pl. XIX, fig. 11); and it lies in a tubular cavity just large enough to receive it, the direct continuation of the genital atrium.

*Monocotyle*—The connective-tissue penis is in this genus a somewhat pear-shaped organ attached to the body by its smaller end at the bottom of the genital atrium (Pl. XVIII, fig. 3), and is perforated by a canal. The substance of the penis consists of fibres which are of similar general appearance to those of the suckers of *Microcotyle* and some other genera, but are finer and stain better with haematoxylin. They are arranged perpendicularly to the surface of the penis, and at its base are seen to be directly continued into the mesenchyma of the body, which, however, consists in this region of a



finely fibrous, compact connective tissue (Pl. XVII, fig. 3). The chitinous penis is similar to that of *Calicotyle*, but is shorter and more slender (Pl. XVII, figs. 1 & 2; Pl. XVIII, figs. 3 & 7), and is somewhat spiral. Its base is directly applied to the termination of the vas deferens, and lies enclosed in the tubular cavity of the penis with only its terminal part projecting into the genital atrium under the usual circumstances.

*Tristemonum* and *Ephibdelia*.—In these genera the chitinous penis is entirely wanting, and in both, the penis is nearly alike in structure as well as in position relative to the other parts of the genital organs. Unlike all the genera hitherto described, the common genital pore, or in some species the separate male and female openings, are situated quite in the lateral part of the body, a little behind the left anterior sucker. The penis is an elongated, hollow, subconical body projecting for the greater part of its whole length into the genital atrium. The basal portion of the penis is separated from the surrounding mesenchyma by a thin, dense layer of connective tissue which vividly takes up the stain. This layer is, however, absent for a certain extent at the very base of the penis, so that here the substance of the penis is directly continuous with the general mesenchyma of the body (Pl. XXII, fig. 2). The cavity of the penis is tubular for the greater part of its length, but at its base it is enlarged spherically and receives the openings of the prostate glands.

The substance of the penis is somewhat different in histological structure in different species; but generally it consists of a loose, reticulated, fibrous connective tissue (Pl. XXII, fig. 4; Pl. XXIV, fig. 1). In those species the mesenchyma of which is more or less of a syncytial nature, as *Trist. sinuatum*, the meshes of the connective tissue are filled with a granular substance; but the fibrous element seems always to preponderate in the penis (Pl. XXII, fig. 4). Towards the

internal and external surfaces of the penis, the connective tissue is replaced by a granular, or a uniformly staining, homogeneous, substance. In *Tristomum orale* I have observed in the substance of the penis numerous, small, spherical, vesicular bodies which stain deeply with hæmatoxylin (Pl. XXIV, fig. 1), and which are quite different from the nuclei of the mesenchyma, but may be their remnants. In the species just mentioned and in *Trist. biparasiticum* the internal surface of the tubular cavity of the penis is raised into numerous subconical or mound-like elevations closely crowded together and pressed against one another (Pl. XXIV, fig. 1); in *Trist. foliaceum* also there are similar papillæ, but they are much smaller. These papillæ consist of a coarsely granular substance which stain deeply with hæmatoxylin. Internally this granular substance passes gradually into the fibrous connective tissue.

The penis is provided with a musculature of its own, which consists of four sets of fibres, *viz.*, the *internal* and the *external circular* fibres, the *longitudinal*, and the *retractor* fibres. Of these the external circular fibres are by far the most strongly developed. In *Trist. orale* (Pl. XXIV, fig. 1) they form a layer about  $10\mu$  in thickness just inside the external membrane of the penis, but separated from it by a small interval. Next these come the longitudinal fibres which do not form bundles, the individual fibres being separated from one another by greater or less intervals. They are direct continuations of some of the longitudinal muscular fibres of the body, and are attached at the apex of the penis to its external limiting membrane. The internal circular fibres are situated just inside the internal limiting membrane of the penis, or in those cases where the internal surface of the penis is raised into papillæ, just at the base of these, and are, so far as I have observed, arranged in a single row. The individual fibres are also smaller than the external circular fibres. The retractor

muscle consists of a few fibres, which are attached to the base of the penis a little towards one side.

It is perhaps hardly necessary to remark that the relative thickness of the different layers of muscular fibres just described varies according to the species.

Under the usual circumstances the penis lies completely in the genital atrium; but it is sometimes seen projecting from the opening of the atrium, which is then thereby forcibly enlarged (Pl. XXIII, fig. 8).

*Onchocotyle*.—In this genus the penis is very different from those hitherto described, at least in its relation to other parts of the genital ducts. It does not, namely, project into a genital atrium—this is indeed entirely wanting in this genus—or into a homologous cavity, but is constituted simply by a mass of peculiar connective tissue around the terminal portion of the vas deferens, which therefore, consistently with our nomenclature, is to be called the *ductus ejaculatorius* (Pl. XVI, fig. 7). This mass of connective tissue is, roughly speaking, conical in shape, and is separated from the surrounding mesenchyma by a thin layer of well staining, dense, fibrous connective tissue, just as in *Tristomum*. But unlike what is seen in that species the substance of the penis consists of a strongly refringent, somewhat yellowish, structureless substance which does not stain with hæmatoxylin, but which is traversed by more or less well staining, reticulated fibres. It contains a small number of nuclei which are perfectly like those of the surrounding mesenchyma, and are sometimes surrounded by a granular protoplasm (Pl. XV, fig. 10; Pl. XVI, fig. 7). The *ductus ejaculatorius* makes numerous windings in the penis, and finally opens into the uterus just before this opens to the exterior.

*Axine, Hexacotyle, and Microcotyle reticulata*.—Strictly speaking there is no separate organ that can be called penis in these forms ;

but the mesenchyma around the terminal portion of the vas deferens has assumed a character more or less different from that of the other parts ; and although it is not so distinctly separated from the remaining portion as in *Onchocotyle*, it still forms doubtless the morphological equivalent of the penis. Physiologically, too, this portion seems to deserve the name, since in *Hexacotyle* (Pl. XII, fig. 6) numerous muscular fibres take rise from the papilla on the top of which the vas deferens opens, and taking mostly a direction backwards are inserted into the dorsal wall of the body. These constitute doubtless the retractor muscle. In *Aciue* (Pl. VII, fig. 5 ; Pl. VIII, fig. 3) I have not been able to demonstrate the presence of any retractor ; but the terminal portion of the vas deferens is surrounded by a mass of connective tissue which is very similar to that of the penis of *Onchocotyle* with the only difference that the meshes are closer and the fibres finer, and which remains wholly unstained by borax-carmin. An exactly similar tissue is present in *Microcotyle reticulata* (Pl. V, fig. 6), a species which approaches in many respects the genus *Aciue*. Had a membrane been developed around this peculiar mass of connective tissue nobody would hesitate to call it the penis ; but as it is, we can not give it a distinct boundary. Physiologically, however, there is little doubt that this tissue acts as a true penis ; for in *Microcotyle reticulata* and *Aciue aberrans* the internal surface of this part of the vas deferens is armed with numerous chitinous spines (Pl. V, fig. 6 ; Pl. VII, fig. 6 a). In the former species each spine consists of a hemispherical, basal portion and a spinous, distal portion, and is perfectly straight ; in the latter species the spines are simple and are slightly curved. It is difficult to conceive the use of these spines unless the portion that bears them can be evaginated.

The chitinous copulatory organ of *Microcotyle* is somewhat different from those hitherto described, and will be treated of in connec-

tion with the genital atrium. In *Hexacotyle* the homologue of the connective-tissue penis of such genera as *Tristomum*, *Epibdella*, and *Monocotyle* is present in the form of a conical papilla at the top of which opens the vas deferens, as will be explained under 'General Considerations.'

GLANDULA PROSTATICA—So far as I know, the prostate gland has hitherto been described only in *Tristomum* among the ectoparasitic Trematodes; but according to my observations it is present in all the genera described in this paper. Only in *Octocotyle* I have not been able to demonstrate it owing to scantiness of the material and its bad preservation. Even early in the course of my present studies my attention was drawn to cells of a peculiar appearance around the vas deferens, which were very unlike those of the mesenchyma; but their nature long remained to me a problem. In *Aciac* (Pl. VIII, fig. 1) and *Microcotyle* (Pl. III, fig. 10; Pl. V, fig. 6) they always occupy the median portion of the body, and in some species this portion is almost wholly occupied by these cells to the exclusion of all others (Pl. III, fig. 10). They are of a rounded or more frequently of a polygonal outline, with a finely granular, deeply staining protoplasm destitute of any distinct external membrane. In *Microcotyle* the nucleus is usually very large and contains one or more nucleoli; but in *Aciac* it is smaller (Pl. VIII, fig. 1). In *Monocotyle* also, peculiar cells can always be observed in the mesenchyma around the vas deferens (Pl. XVIII, fig. 2. *pros. gl.*) which always form a group very conspicuous in sections. The individual cells are in this case provided with a membrane of its own, and are more or less vacuolated, the granular protoplasm forming simply a thin layer just inside the cell-membrane, or radiating in threads from the nucleus towards the periphery, or sometimes distributed uniformly but thinly through the cell-body. The form of the cells is either polygonal or globular, and the

nucleus which mostly occupies a central position is very small and contains a single or a few small nucleoli. In this genus as well as in *Axine* and *Microcotyle* the cells in question are mostly present around the terminal half of the vas deferens and are entirely absent near the testes. As I have said above, these cells remained to me an enigma for a long time ; judging from their appearance I was tempted to attribute to them a secretory function. Fortunately, however, the study of *Hexacotyle* in the latter part of my studies solved for me the enigma. In some sections of *Hexacotyle acuta*, one of which I have reproduced in fig. 5, Pl. XII, I could distinctly trace the efferent ducts of numerous cells around the vas deferens having a coarsely granular protoplasm. These cells seemed to be destitute of any membrane, were of an irregularly polygonal shape, and their nuclei contained each a single or sometimes a few nucleoli. They are therefore very similar to the cells already described in *Microcotyle*, except in the coarseness of their protoplasmic granules. Not only could the efferent ducts be distinctly traced up to the thick membrane of the vas deferens, but a granular substance exactly similar in appearance to the contents of the cells above described (except in staining more deeply) could be observed on the inner surface of the membrane, forming numerous prismatic columns. Each of these columns has doubtless been formed by the secretion of a single cell, which is therefore the *prostate gland*. After this observation every one would admit that the peculiar cells around the vas deferens in *Axine*, *Microcotyle*, and *Monocotyle* are of the same nature, since they occupy similar positions and closely resemble one another in their appearance as well as in their reaction towards staining fluids. I have not been able to observe the efferent ducts in the genera just mentioned ; but this is, I believe, owing to the fact that the glandular cells were in the state of rest when the animal was killed. At least in the case of the shell-glands afterwards to be described, the

efferent ducts can not be observed when the cells are not in an active state. I believe Lorenz<sup>1)</sup> had the prostate glands before him when he speaks of cells around the uterus, which had a granular protoplasm.

In *Dictidophora* the prostate glands are more scattered than in the genera hitherto treated of, and are especially abundant around the terminal portion of the vas deferens. In this genus also, the cells are wholly destitute of external membrane, the protoplasm is finely granular, and the nuclei, which are more or less vesicular in appearance, vary much in size. The larger ones are more or less oval, and contain a large nucleolus enclosing a vacuole, and a few smaller nucleoli. After secretion the cells seem to shrink to a very small size, and in these shrunken cells the efferent ducts are very distinct (Pl. XI, fig. 4). The interior of the vas deferens is filled with numerous coarse granules, evidently the secretion of the prostate glands. This secretion seems to form at first a single drop for each cell and then to break up into numerous, smaller granules (Pl. XI, fig. 4). In *Onchocotyle* the prostate glands are present not only around the vas deferens, but also on the more ventral side of the body (Pl. XVI, fig. 8). The cells are very similar to those of *Hevacotyle*.

In *Epibolella* the prostate gland is an egg-shaped, or elongated cylindrical, hollow body, lying just behind the penis and communicating with its cavity either directly or by means of a short canal (Pl. XXVI, figs. 1, 3, 4, & 6). In *Epib. ovata* (fig. 6) the wall is composed of a coarsely granular, well staining substance, and has a distinct basement membrane which separates it from the mesenchyma. In a specimen of *Epib. Ishikawai* which I examined, the cavity contained a well staining, homogeneous coagulum which looked very

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1). Lorenz—Ueber die Organisation der Gattungen *Aeine* u. *Microcotyle*. Wiener Arbeiten, Bd. 1, 1877, p. 8.

much like the albuminous substance contained in the egg-capsules of the earthworm and other animals when coagulated ; and the wall was completely shrunken, apparently owing to the great secretory activity which produced the coagulum. I have not, however, been able to study the minute structure of the gland in this genus owing to scantiness of the material and its imperfect preservation ; and I must therefore content myself with the above meagre account. What von Linstow<sup>1)</sup> calls the “Samenblase” in *Phylline Hendorffii* and P. J. v. Beneden<sup>2)</sup> the “vésicule séminale” situated outside the penis in *E. Hippoglossi*, is undoubtedly the prostate gland. I also think that what St.-Remy<sup>3)</sup> calls the “vésicule prostatique accessoire” is nothing else than a portion of the prostate gland which seems, in *Phyllonella solea* according to that writer's account, to consist of numerous lobes.

In *Tristomum* the prostate gland is much developed and has been already observed by my predecessors. It consists of numerous unicellular glands with exceedingly long necks, which in some species, *e. g.*, *Trist. foliaceum*, are arranged distinctly in two separate groups (Pl. XXV, fig. 9). The cells themselves are scattered without any order through the mesenchyma of the median and lateral portions of the body around the foremost part of the vas deferens (Pl. XXII, fig. 1). They present somewhat different aspects according to the different states of their secretory activity. They are either polygonal or spherical, but are of very different sizes ; the smaller ones stain deeply and their protoplasm is finely granular, while the larger ones have a more coarsely granular and more weakly staining protoplasm. The nucleus is always very distinct ; it is vesicular, and contains

1). Von Linstow—Beitrag zur Anatomie von *Phylline Hendorffii*. Archiv f. mik. Anatomie, Bd. 33, 1889, p. 171.

2). P. J. v. Beneden—Mémoire sur les vers intestinaux. p. 29 & Pl. III, fig. 1.

3). St.-Remy—Étude de l'appareil génital chez les *Tristomiens*, p. 17.



one or several nucleoli. The efferent ducts are exceedingly long and variously cross each other in their course. When the cells are active these ducts are filled with a weakly staining, granular substance exactly like in appearance to that of the cells themselves. In this case their wall is very distinctly visible, but in the intervals of secretion it seems to collapse entirely, and the ducts are then no more visible.

In the genus under consideration the prostate glands enter the penis at its base a little towards one side (Pl. XXII, fig. 2), and open into its cavity. Just before entering the penis, the ducts are often filled to such a degree as to be partially stopped up, and at this point often present in consequence a ruggedly swollen appearance (Pl. XXV, fig. 8).

In *Epibdella* I have observed a pair of peculiar egg-shaped organs on either side of the median line just behind the testes (Pl. XXV, figs. 4 & 6, *x*). In sections they are seen to be a mass of polygonal cells, each of which contains a nucleus with a nucleolus, and has a coarsely granular, slightly staining cytoplasm (Pl. XXVI, fig. 8), the whole mass being provided with a distinct limiting membrane. Judging from their appearance and reaction towards staining fluids I should consider them as glands, but I have not been able to find out any duct or any connection with the neighbouring organs.

(b). *The Female Organs.*

OVARY—The ovary is always single and is simply a cavity in the mesenchyma filled with germ-cells. Unlike what is seen in the testes, however, the cavity is usually bounded by a thin membrane of connective tissue, closely applied to which are sometimes observed oval or flattened nuclei (Pl. IV, fig. 8); but these are in my opinion to be regarded as the nuclei of the mesenchyma, and not as

the remnants of the original epithelium of the ovary. When the ovary is more or less elongated the zones of formation and growth can be very clearly distinguished; the maturation of the ovum taking place probably after its enclosure in the egg-shell. In *Microcotyle* and in most species of *Aciur* (Pls. I, II, & VII) the ovary is more or less S-shaped when looked at from the dorsal side of the body; in some species the lower half of the S is drawn out almost straight, while in some others this portion is coiled spirally on itself (Pl. II, fig. 6). The formative zone is situated at the posterior end of the ovary, and looks in sections as a continuous mass of homogeneous protoplasm in which numerous nuclei lie imbedded. These are provided with a distinct membrane and contain numerous granules of chromatin. As we proceed away from this into the growing zone the protoplasm becomes more and more distinctly separated around each nucleus, or, in other words, the ova gradually acquire their independence; the nuclei become larger and larger, the chromatin granules become more and more undefined, and a distinct nucleolus makes its appearance in each nucleus; until finally in the terminal part of the ovary, *i. e.*, in that part where the oviduct takes its rise, each ovum is provided with a large, clear, thin-walled, vesicular nucleus containing, besides numerous, faint, minute granules of chromatin, a single large nucleolus, which takes up all stains with extreme avidity and encloses a single large or several smaller vacuoles (Pl. IV, figs. 8 & 9; Pl. VII, fig. 3; Pl. IX, fig. 6; Pl. X, fig. 8; Pl. XV, fig. 6; Pl. XVIII, fig. 6; Pl. XIX, fig. 13). In *Aciur aberrans* (Pl. VII, fig. 5) and in *Octocotyle* (Pl. IX) the ovary is an elongated, cylindrical body which is bent on itself at its middle, so that its ends come to be apposed to each other, and which is placed with its long axis parallel to that of the body. In *Calicotyle* (Pl. XIX, fig. 1) too it is a very long, slender body bent on

itself at the middle, so as to form a loop across the length of the body; but in this genus the proximal end of the ovary, *i. e.*, the zone of formation, is enlarged into a globular shape, while the remaining portion is throughout of an almost uniform thickness so that Wierzejski<sup>1)</sup> was led to call this portion the oviduct (Eileiter). But that it corresponds in reality to the zone of growth is very clear from a comparative study of the ovary in different genera. What seems to be very peculiar is that the closed end of the loop which the ovary forms in this genus encircles the intestine (Pl. XIX, fig. 1). This is also the case in *Monocotyle*; but in this genus the formative zone passes gradually into the zone of growth, and the whole ovary makes an additional large winding or two (Pl. XVII, fig. 1).

In *Dictylophora* the form of the ovary varies much in different species. The simplest form is found in *Dictyl. elongata*, in which a long cylindrical ovary is twice bent on itself so that each half is horse-shoe shaped (Pl. X, fig. 9). In *Dictyl. sessilis* also, each half of the ovary is bent on itself so that the whole looks somewhat like the letter W; but the four arms of the W are closely applied to each other, and the terminal portion, *i. e.*, that which gives rise to the oviduct is very much larger than the other three, and contains a cavity filled with a sparsely fibrous connective tissue (Pl. X, fig. 5). In *Dictyl. tetradonis*, again, the somewhat comma-shaped ovary makes a spiral winding to one side at its middle, so that the whole looks somewhat like the embryo of the chick in profile, with its large heart protruding from its ventral side at a short distance from the head (Pl. X, fig. 1); the head of the embryo answering to the oviduct end of the ovary and the tail end to the formative zone. In *Oncocotyle* the zone of formation occupies about one-fifth of the whole length

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1) Wierzejski—Zur Kenntniss des Baues von Callicotyle Kroyeri. Zeitschr. f. wiss. Zoolog., Bd. 29, 1877, p. 557.

of the ovary, is of an irregular shape, and occupies a position anterior to the rest of the ovary (Pl. XV, fig. 1, *ov*). The remaining part is twice bent on itself at equal distances apart so that it may be considered as consisting of four portions united end to end. The oviduct portion is very much larger than the other three portions.

In *Hexacotyle* the ovary makes numerous, exceedingly complex windings which can not be described with any degree of clearness, and the reader is therefore referred to figs. 1 & 7 of Pl. XIV. In *Hexacotyle acuta* I have not been able to obtain a general view of the whole ovary, and fig. 1 on the plate just referred to has been composed from a series of sections, controlled as much as was practicable by examinations of the specimens mounted *in toto*. The general form of the ovary is that of a long cylinder bent on itself at its middle portion, each half of which makes numerous convolutions.

In *Epibdella* the ovary is a simple, spherical body, in which the zones of formation and growth can not be distinctly separated from each other, but the younger ova are found towards the periphery, while the riper ones are situated in the central part. In some species of *Tristomum* also the ovary is simply an irregularly globular body; but in most species it consists of a certain number of more or less distinct lobes, which are incompletely separated from one another by an intervening layer of connective tissue, all however freely communicating with one another at the centre of the ovary. As in *Epibdella* the unripe ova occupy the periphery, while the riper ones are situated more in the central part.

The ovarian ova are in all the species totally destitute of any external membrane.

oviduct—As I have stated elsewhere,<sup>1)</sup> I designate by this

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1). Centralblatt f. Bakteriologie u. Parasitenkunde, Bd. XIV, 1893, p. 798.

name that portion of the female efferent duct that lies between the ovary and the ootyp, the beginning of the latter being always distinctly marked by numerous unicellular shell-glands. Its course and its relation to other genital ducts are very different in different species, and will be described afterwards for each species in the systematic part, but some of its common features must be noted down here. It lies, namely, in all the species dorsal to the unpaired yolk-duct, and communicates with it as well as with the *canalis genito-intestinalis* when such is present. In *Microcotyle*, *Acine*, *Oncocotyle*, *Dictidophora*, and *Calicotyle* it bears the *receptaculum seminis*. In the first two genera just mentioned this organ is formed simply either by a lateral evagination, or by the swelling of a portion, of the oviduct; and seems to be actually present only when it is filled with sperm mass, and to shrink together when there is no sperm to fill it, so that then it seems as if entirely wanting. In *Dictidophora* the *receptaculum seminis* is exceedingly large, and is very conspicuous, especially in *Dictid. sessilis* (Pl. X, fig. 5). In this species it is a very large sac situated on the median line of the body just behind the ovary, and consists of numerous lobes. These lobes are mostly situated on the dorsal side of the body, and are separated from each other by a thin layer of connective tissue. They all converge towards the oviduct as a centre, and communicate with it just where it makes a short forward bend to meet the unpaired yolk-duct (Pl. X, fig. 5; Pl. XI, fig. 5). In cross-section the cavities of the lobes are seen to be destitute of any distinct lining membrane. In all the specimens I have examined, they were always completely filled with sperm-mass. In *Dictid. elongata* the seminal receptacle is also large, but is considerably smaller than in *Dictid. sessilis*, and is simply globular in shape (Pl. X, fig. 9). In *Dictid. tetrolomis* I have not observed any seminal receptacle, but this was, I believe, owing to the absence of any sperm

mass at the time. I think this the more probable, as the only specimen I have examined had numerous eggs in its uterus, in the formation of which all the sperm mass that may have been present in the seminal receptacle would have been used up (Pl. X, fig. 1).

In *Onchocotyle spinacis* the seminal receptacle is a tolerably large, ellipsoidal sac situated just in front of the ovary, and is provided with a long stalk, by means of which it communicates with the oviduct at the point where the latter receives the unpaired yolk-duct and the genito-intestinal canal (Pl. XV, figs. 1 & 2). It therefore presents some difference from that of *Oncho. appendiculata*, in which it is, according to Taschenberg, merely a local enlargement of the oviduct.

Close to the ovary the wall of the oviduct consists of a thin structureless membrane; but as we approach the ootyp there is a thin layer of homogeneous or very finely granular substance probably of a protoplasmic nature, which stains pretty well with haematoxylin, so that the membrane just referred to above is in reality a true basement membrane with probably a very thin protoplasmic layer on its inner surface. I have nowhere been able to observe any nucleus in the wall of the oviduct; but that it originally consisted of a true epithelium seems to me beyond doubt, from the presence of the protoplasmic layer already mentioned, and from the fact that nuclei are present in other parts of the female efferent duct. In *Dictidophora* the oviduct presents at short intervals circular thickenings of its wall exactly similar to those which will be described afterwards in the genito-intestinal canal.

OOTYP—The ootyp is a spindle-shaped portion of the female efferent duct situated between the oviduct and the uterus, where the ovum and the yolk-cells become enclosed together in the egg-shell. In many species it is always distinctly set off from the other parts of

the female duct by its constant form; but in *Microcotyle*, *Axine*, *Octocotyle*, *Dictidophora*, *Hexacotyle*, and *Onchocotyle*, it can not be distinguished superficially from the other parts unless during the period of reproductive activity. It is, however, usually well characterised by the fact of its receiving the openings of numerous unicellular shell-glands either throughout its whole extent, as in *Axine*, *Microcotyle*, *Octocotyle*, *Dictidophora*, *Onchocotyle*, and *Hexacotyle*; or, as in *Tristomum*, *Epibdella*, *Calicotyle*, and *Monocotyle*, only at the beginning of the ootyp. In most genera of the first group the shell-glands are situated only around the ootyp; but in most species of *Microcotyle* they are present not only around the ootyp but also at some distance behind it (Pl. IV, fig. 4), so that those that are far removed from the ootyp come to be provided with long efferent ducts, which then open close to each other at the very beginning of the ootyp. When the glands are active these efferent ducts are filled with a granular substance, evidently the product of secretion, which stains deeply with haematoxylin (Pl. IV, fig. 4). It is undoubtedly these ducts which Lorenz<sup>1)</sup> has described as the "Quaste." In *Microcotyle* the shell-glands form, moreover, a compact mass around the ootyp, which looks usually triangular in cross-section (Pl. IV, fig. 8), owing to the pressure of the neighbouring organs. In other case, where the glands are free from any pressure, they are arranged almost uniformly on all sides of the ootyp, as in *Axine*, *Hexacotyle*, *Octocotyle*, and *Dictidophora*.

In *Onchocotyle* the shell-glands are divided into four groups owing to the intervention of other organs (Pl. XVI, fig. 3). There are two groups on the dorsal side and two on the ventral side of the body, the groups on the same side being separated from each other in

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1). Lorenz—Ueber die Organisation der Gatt. *Axine* u. *Microcotyle*. Wiener Arbeiten, Bd. I, 1878, p. 17 & 27.

the median line. The cells, especially of the ventral groups, are far removed from the ootyp; and they are therefore provided with long efferent ducts, which open into the ootyp after making more or less windings on the way (Pl. XVI, fig. 4). In *Tristomum* also, the shell-glands are far removed from the ootyp, and open by means of long ducts into its very beginning (Pl. XXII, fig. 3). In some species of this genus (*e. g.* *Trist. sinuatum*) the wall of the ootyp sends out a few small, tubular evaginations, into which the shell-glands open (Pl. XXII, fig. 6). In *Monocotyle* too, these glands are provided with long stalks, and open only at the beginning of the ootyp.

As to the shell-glands themselves, they are in most species of an irregular polygonal form. The nucleus is more or less vesicular and contains one or a few nucleoli; the protoplasm is usually granular, stains well, and is wholly destitute of any external membrane. The glands, however, often appear like small naked nuclei, owing to the shrinkage of their protoplasm. This condition is evidently owing to exhaustion, and corresponds to the period of complete rest. In *Monocotyle* the shell-glands are ellipsoidal or spherical, and are, as already stated, provided with long stalks (Pl. XVIII, fig. 1). The nucleus, which contains in this case usually a single nucleolus, occupies a more or less eccentric position, and the cytoplasm is finely granular and stains weakly. The ducts are on the other hand often filled with a more deeply staining, and more coarsely granular substance; the cytoplasm and the contents of the duct being sometimes separated by a sharp line (Pl. XVIII, fig. 1). I do not know what interpretation to put on this phenomenon, except to regard these goblet-shaped cells as having arrived at the culminating point of their secretory activity and to have almost entirely emptied themselves of the product of secretion, leaving only the protoplasm in the body of the cell—in other words, I regard the deeply staining contents of the duct as the product of secretion, and



suppose the cells to shrink soon after discharging their contents. In these goblet-shaped cells just mentioned I could observe a distinct cell-membrane. In the immediate neighbourhood of these cells there are in *Monocotyle* numerous large cells of an irregular shape, each with a rather small nucleus which contains a single nucleolus, and with a coarsely granular, well-staining protoplasm destitute of an external membrane. Judging from their similarity to the shell-glands of other genera and from the fewness of the goblet-shaped cells above mentioned in the genus under question, I think they are shell-glands which are still in the interval in secretory activity.

As stated above, the ootyp is characterised by the fact that it receives the openings of the shell-glands. It is, moreover, separated from the oviduct by a constriction, which is usually very distinct—"une sorte de pylore" as P. J. v. Beneden<sup>1)</sup> calls it. Anteriorly it is in most species directly continued into the uterus without undergoing any constriction; but in many species of *Tristomum* (*T. sinuatum*, *T. orale*, *T. biparasiticum*, and *T. foliaceum*) its anterior extremity protrudes into the hinder end of the uterus, just in the same way as the neck of the uterus projects into the vagina in the mammalia; so that in this genus the uterus and the ootyp may be said to be separated from each other by a valve, which allows a body to pass from the latter into the former but not in the contrary direction (Pl. XXII, fig. 3). In *Monocotyle* the ootyp opens directly into the genital atrium, the uterus being totally wanting in this genus. In *Axine*, *Microcotyle*, *Octocotyle*, *Diclidophora*, and *Hexacotyle* the wall of the ootyp is not specially different from that of the oviduct; *i. e.*, it consists of a thin, homogeneous, protoplasmic layer resting on a basement membrane; but in some species there is an assemblage of oval nuclei at the entrance of the oviduct (Pl. IV, fig. 4). In some cases there

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1) P. J. v. Beneden—Mémoire sur les vers intestinaux, p. 13.

was also a rather thick layer of granular substance on its wall (Pl. IV, fig. 8), which I believe to be the secretion of the shell-glands. In *Onchocotyle* the ootyp presents in cross-section a very peculiar appearance. Its cavity looks stellate, caused by the fact that the cells that constitute its epithelium have assumed a laterally flattened conical form and are arranged in close series in parallel longitudinal lines, so that the wall is, so to speak, furnished with pilasters projecting into the cavity of the ootyp (Pl. XVI, fig. 4). That these pilasters are composed of cells is clear from the fact that here and there in cross-sections nuclei are observed near the outermost end of the sections of the pilasters; the comparative fewness of the nuclei being accounted for by supposing that the cells have been much elongated parallel to the length of the ootyp. The individual cells are completely fused with each other, and no boundary line can be observed; the furrows between the pilasters, however, probably mark the boundaries between the longitudinal series of cells. The wall of the ootyp is separated from the mesenchyma by a distinct basement membrane; but there is no membrane on its inner surface (Pl. XVI, fig. 4). In *Tristomum* the wall of the ootyp consists of a sort of syncytium in which nuclei are sparsely dispersed, and which is separated from the mesenchyma by a basement membrane. The syncytium itself stains well, is very finely granular, and has no membrane on its free surface (Pl. XXII, fig. 3). The nuclei seems sometimes to be very regularly distributed: for instance, in *Tristomum sinuatum* I have observed in a median longitudinal section of the ootyp four nuclei arranged in pairs in the central portion and two others also arranged in a pair near the oviduct end (Pl. XXII, fig. 3); they were all vesicular, stained rather weakly, and contained each a single, deeply staining nucleolus. In *Calicotyle* and *Monocotyle* the wall of the ootyp consists of a true epithelium resting on a basement

membrane and consisting of tall, prismatic cells, each with a small nucleus near the base (Pl. XVIII, fig. 2; Pl. XIX, fig. 7). These nuclei are spherical and vesicular, but stain well, and each contains a single dot-like nucleolus. In *Calicotyle* the boundaries of the cells are distinct; but in *Monocotyle* they become indistinct towards the free surface of the cells. The protoplasm of the cell is finely granular and stains a beautiful purplish blue with Kleinenberg's hæmatoxylin. In the specimens of *Monocotyle* examined by me the free borders of the cells remained almost totally unstained and presented a somewhat stringy appearance, as if a layer had been artificially formed by the sticking together of closely aggregated fine cilia (Pl. XVIII, fig. 2). St.-Remy<sup>1)</sup> considers what I have regarded as the epithelium of the ootyp as of the nature of a connective tissue and calls it "cuticle"; and in support of his view he mentions the fact that although the wall of the ootyp shows a certain tendency towards its external side (*i. e.* the side turned towards the mesenchyma) to break up into irregular prisms, the lines of separation do not correspond with the distribution of the nuclei. From his statements elsewhere I gather that the author does not mean by "une certaine tendance à se dissocier en prismes irréguliers" that he has actually tried to separate these prisms by maceration or other means, but I believe he is here speaking of the lines which I have regarded as cell-boundaries. If so, it is to be observed that even in the case of a true epithelium the boundaries do not always seem in cross-sections to correspond exactly with the distribution of the nuclei, as actually for example, in the intestine of *Monocotyle* and *Calicotyle*. St.-Remy<sup>2)</sup> admits that "il est vraisemblable que dans le jeune âge, il y avait là des cellules;" but he thinks "que cette fragmentation ne correspond pas à leurs limites." It is

1) St.-Remy—*l. c.* pp. 10, 26, 33.

2) *l. c.* p. 26.

after all not clear to me what the author means when he speaks of a "enticle" containing nuclei and of a layer of finely granular, or, as he says, homogeneous substance lining a cavity as being of a connective tissue nature. Comparative considerations seem to me to compel us to regard the wall of the ootyp of *Monocotyle* and *Calicotyle* as consisting of a true epithelium; only in the case of *Tristomum* the cell-boundaries have completely, and in that of *Onchocotyle* partly, disappeared.

In *Tristomum* the mesenchyma around the ootyp presents an appearance very different from that of the rest. Where the general mesenchyma consists of a fibrous connective tissue, the reticulum is always much looser around the ootyp than in the other parts. In *Trist. sinuatum* in which, as already described, the mesenchyma consists of a syncytium, the part around the ootyp contains numerous cavities separated from each other by a thin layer of the syncytium (Pl. XXII, fig. 4). This loose portion of the mesenchyma is, in all the species, surrounded by a layer of muscular fibres, which are of two sorts, those which run parallel to the length of the ootyp and those that run in a dorso-ventral direction. The latter fibres are no other than the dorso-ventral fibres of the body. The two sets of fibres are also present around the uterus, and therefore the farther course of the horizontal fibres will be again treated of under that head. They evidently serve by their contraction to drive out the egg from the ootyp.

Returning to the ootyp of *Monocotyle* and *Calicotyle* and considering the appearance and reaction towards colouring fluids of the cells that constitute its wall, one is, I think, strongly tempted to suspect their glandular nature. But as the shell-glands are present outside the ootyp, I can not conceive any purpose they might serve in case of their being really glands. They are probably a simple lining epithelium, of which, however, the character has undergone a certain

change, perhaps better fitting it to bear the abrasion to which it is necessarily exposed during the formation of the egg-shell.

UTERUS—With this name I designate that portion of the female efferent duct which is continued forwards from the ootyp and opens to the exterior or into the genital atrium when such is present. In *Monocotyle* it is, as already mentioned, wholly wanting, the ootyp opening in this genus directly into the genital atrium. In *Calicotyle* it is very short and is lined by the continuation of the epithelium of the ootyp (Pl. XIX, fig. 7); the cell-boundaries, however, can not be observed satisfactorily. In *Epiplatella* too the uterus is exceedingly short; in fact it may be said to be wanting in *E. Ishikarac*. On the other hand, in *Aeine*, *Microcotyle*, *Hexacotyle*, *Octocotyle*, and *Dictidophora* the uterus is very long, and its wall consists of a membrane which is in most cases very thin, but sometimes very thick and refringent, as in *Microcotyle reticulata* and *Aeine heterocerca* (Pl. V, fig. 5; Pl. VII, fig. 1). In *Octocotyle*, *Hexacotyle*, *Onchocotyle*, and in all the species of *Microcotyle* except *M. sciencu* (Pl. VI, fig. 2), the inner surface of the uterine wall is covered with cilia; but in all the other species treated of in this paper it is entirely naked (Pl. V, figs. 1, 2, 3, 4, & 5; Pl. VI, fig. 4; Pl. IX, fig. 12; Pl. XIV, fig. 3). In *Aeine heterocerca* and *Dictidophora sessilis* the uterus is provided with a double layer of muscular fibres consisting of the inner longitudinal and the outer circular fibres (Pl. VII, fig. 1; Pl. XI, fig. 4). In *Hexacotyle*, on the other hand, only the circular fibres are present.

The uterine wall of *Onchocotyle* presents some peculiar aspects and deserves a separate description. Close to the ootyp the wall of the uterus presents an aspect closely similar to that of the ootyp (Pl. XVI, fig. 5); only the pilasters are lower and spindle-shaped in cross-section, and some of them are seen to contain nuclei, which are mostly oval and contain each a single nucleolus. Those that do not contain

nuclei, *i. e.*, those whose nuclei have not met the section, are seen to contain one or several vacuoles in their protoplasm (Pl. XVI, fig. 5). The top of each pilaster is seen in section to bear numerous cilia. As we recede from the ootyp, the pilasters become more and more flattened, the cilia become longer, and the nuclei finally disappear altogether; but the pilasters are still separated by a shallow furrow, (Pl. XVI, fig. 6). As we recede still farther from the ootyp the pilasters finally disappear entirely, *i. e.*, the protoplasmic remnants of the original epithelium have almost wholly disappeared, and the inner surface of the uterine wall is covered uniformly with long, stout cilia (Pl. XV, fig. 10; Pl. XVI, fig. 8). In this genus there is no genital atrium, and the uterus consequently opens directly to the exterior by means of a small pore (Pl. XVI, fig. 7).

Monticelli<sup>1)</sup> thinks that in *Onchocotyle* the terminal portion of the uterus is specialised into an "ovidotto esterno"; but I think the enlarged portion figured by Taschenberg is due to the eggs that are contained therein. So far as I have observed there is in the *Monogenea* no specialised portion corresponding to Monticelli's "ovidotto esterno."

In most species of *Tristomum* the posterior end of the uterus is, as already stated, enlarged into the shape of a funnel with its mouth directed towards the ootyp, the front attenuated end of which projects into it. It is usually of uniform size throughout the rest of its extent; but in *Trist. sinuatum* I have observed it undergo another enlargement and then to be reduced to a narrow canal of uniform calibre (Pl. XXII, fig. 2). The wall is in all cases formed throughout of a thin, structureless membrane. In *Trist. ovale* and *Trist. rotundum* the uterus opens directly to the exterior, close beside the male genital opening (Pl. XXIII, fig. 8; Pl. XXIV, fig. 6); but

1). Monticelli—Primo contributo etc. p. 118.

in all the other species it opens into the genital atrium at various distances from its external opening (Pl. XXI, fig. 8; Pl. XXII, fig. 2; Pl. XXV, figs. 3, 8, and 9).

As already mentioned above, there are in this genus two sets of muscular fibres in the loose connective tissue around the uterus, which are exactly similar to, and one of which is the direct continuation of, those around the ootyp. The dorso-ventral fibres are present only around the lower part of the uterus; but the horizontal fibres are continued to the margin of the body, where they become continuous with the diagonal fibres of the body (Pl. XXII, fig. 4).

VITELLARIUM—This is a very extensive organ situated mostly in the lateral portions of the body and extending through the greater part, or in some species throughout the whole length, of the body (*Tristomum*, *Epibdella*). In accordance with its position in the body, it consists of two parts, a right and a left half, which remain in many species entirely distinct throughout their whole extent; but in other species they pass into each other at both ends. Again, in most species, the vitellarium seems to be closely connected with the intestine in its arrangement, beginning and ending with the main intestinal trunks. In *Microcotyle* this relation is especially conspicuous. As already mentioned, the two trunks of the intestine are in some species of this genus of unequal lengths; and then the halves of the vitellarium also show a corresponding asymmetry, as in *M. elegans* (Pl. I, fig. 4) and *M. sciencur* (Pl. II, fig. 6). There are, however, also species in which the vitellarium and the intestinal trunks do not show any correspondence of lengths, as *M. caudata* and *M. sebastis* (Pl. I, figs. 1 & 2). Again, in many species in which lateral branches of the intestinal trunks are given off towards the median line, these are accompanied by the vitellarium, which then surrounds them on all sides. In *Axine*, *Microcotyle*,

*Octocotyle*, *Diclidophora*, *Onchocotyle*, *Monocotyle*, and *Calicotyle* the front attenuated portion of the body is entirely free from the vitellarium; the hinder caudal portion is also mostly free from it; but to many species this statement does not apply. In *Diclidophora tetradonis* which has a very elongated body, the vitellarium is wholly absent from the whole slender posterior portion. In many species of *Tristomum* the vitellarium occupies not only the whole lateral portions of the body but extends also into the median portion (*T. ovale*, *T. Nozarae*). In *Microcotyle*, *Octocotyle*, *Diclidophora*, *Monocotyle*, *Calicotyle*, *Epibolella*, and in most species of *Tristomum* the vitellarium is present on the dorsal and ventral sides of the body alike; but in *Acinu* the ventral side is mostly free from it (Pl. VII, fig. 1), and in *Trist. ovale* the dorsal side of the median portion of the body is entirely occupied by the vitellarium, which thus leaves only the ventral side for the testes (Pl. XXIII, fig. 7). In *T. Nozarae* too the vitellarium occupies in the median portion of the body a position nearer the dorsum than the testes; but in this species the vitelline lobes are more sparsely distributed in this region.

The vitellarium consists of numerous lobes, which are in most species more or less rounded, but are tubular in *Calicotyle*, so that in this genus the vitellarium consists of a system of tubes filled with yolk-cells. In *Monocotyle*, *Onchocotyle*, *Tristomum*, *Octocotyle*, and in most species of *Microcotyle* and *Diclidophora* these lobes are very closely aggregated, and leave only a very thin layer of mesenchyma between them, so that they are very difficult to distinguish from each other in sections (Pl. IV, fig. 7; Pl. XI, fig. 3; Pl. XVIII, fig. 5); but in all the other species the lobes are separated from each other by a more or less thick layer of the intervening mesenchyma. For instance, in *Hexacotyle* each lobe is surrounded on all sides by the mesenchyma, which thus completely separates it from its neighbours (Pl. XI, fig. 8;



Pl. XIV, figs. 2 & 6); while in *Calicotyle* and *Microcotyle reticulata* the vitelline lobes are distinctly but less completely separated from each other (Pl. III, fig. 4; Pl. XIX, fig. 9). In *Tristomum* (Pl. XXI, fig. 7) and *Calicotyle* (Pl. XXI, fig. 9) I have observed a thin but distinct membrane surrounding the lobes; but in most other genera they seemed to be contained in mere cavities of the mesenchyma destitute of any lining membrane.

The yolk-cells contained in the lobes present different aspects according to the stages of development. The ripe cells are of very different size<sup>1)</sup> in different genera; but present nearly the same aspect in all. While in the vitellarium, they are of various forms according to the pressure of the neighbouring cells; but when freed they invariably assume the form of a regular sphere. Each cell is provided with a distinct, refractive membrane (of tolerable thickness in *Monocotyle Ijima*, Pl. XVIII, fig. 5), and contains numerous, yellow, refringent granules. The vesicular nucleus usually occupies a central position, generally stains well, and contains a single nucleolus; it sometimes loses its affinity for stains, but always subsists to the very last. The protoplasm seems mostly to have entirely disappeared in the ripe cells; but sometimes it remains as a slightly staining network between the yolk-granules (Pl. XXI, fig. 7). Besides the ripe yolk-cells above described, there are, especially in the peripheral part of the vitelline lobes, intensely staining cells of a much smaller size, closely pressed against one another, and with a homogeneous or, in the larger ones, a finely granular protoplasm. The nucleus is clear and vesicular.

1). I append here in the form of a foot-note the results of the measurements of yolk-cells in different species. The figures give the diameter, and are in most cases the average of a number of measurements (not less than five): *Acine heterocerca*, 0.03 mm.; *Microcotyle caudata*, 0.035 mm.; *M. reticulata*, 0.015 mm.; *Diclidophora tetradonis*, 0.022 mm.; *Diclid. sessilis*, 0.028 mm.; *Onchocotyle spinavis*, 0.032 mm.; *Monocotyle Ijima*, 0.0181 mm.; *Epibalella acuta*, 0.021 mm.; *Tristomum rotundum*, 0.015 mm.; *Tr. foliaceum*, 0.019 mm.; *Tr. orale*, 0.016 mm.; *Tr. sinuatum*, 0.018 mm.;

and contains a single small nucleolus. It appears in some cases to be more weakly stained than the protoplasm; but this is, I believe, owing to the entire absence of any granules from the nuclear fluid, which, in consequence, appears very clear and transparent. However, the nucleus itself stains equally or often a little more deeply than the protoplasm. As these yolk-cells grow and become larger, the protoplasm becomes more and more coarsely granular and stains less, until at last the whole protoplasm is replaced by the yolk-granules already described. In some cases I have observed cells one half of which contained only yolk-granules, while the other half had still a coarsely granular protoplasm (Pl. IV, fig. 7). Lorenz<sup>1)</sup> had perhaps the young yolk-cells above described before him when he mentions the occurrence, directly inside the muscular layer of the body, of small cells (0.006 mm.) having a strong affinity for carmin, and the central parts of which remain clear and contain each a dot-like body. Considering that the yolk-cells are drained off in considerable numbers during the period of reproductive activity, one would very naturally expect to meet with the phenomena of division among the young yolk-cells, and it appears to me somewhat remarkable that I have never been able to observe in them any division either direct or mitotic.

YOLK-DUCTS.—In most genera the primary yolk-ducts that proceed from the lobes could not be observed; but in *Tristomum* I could often observe them in sections (Pl. XXI, fig. 7). They have a very small calibre, and are provided with a thin but distinct, membranous wall. In other species I have often observed yolk-cells passing out from the lobes, but the ducts seemed to close together as soon as the cells had passed along, so that their presence could not be recognised any longer. In *Tristomum* again, the secondary and tertiary ducts were usually filled with yolk-cells, and could be easily recognised in

1) Lorenz *l. c.* p. 5.

surface views. The numerous ducts that proceed from each half of the vitellarium at last unite with one another and form a single large duct, the paired yolk-duct. These are in most species symmetrically disposed with respect to the median line of the body, but in *Heracotyle* that of the right side is situated much more in front of the left (Pl. XIV, figs. 1 & 7). In *Diecidophora* a similar asymmetry is also observable, but is not so striking (Pl. X, figs. 1, 5, & 9); and in this genus the relative positions of the ducts of the two sides of the body are the reverse of what is found in *Heracotyle*, the duct of the left side being situated anterior to its fellow of the opposite side. During the summer season the paired yolk-ducts are almost always filled with yolk-cells, and are consequently very conspicuous, being sometimes perceptible with the naked eye through the transparent tissue of the worm. In *Acine heterocerca*, *Microcotyle*, *Heracotyle*, and *Ouchocotyle* they run for the greater part of their lengths parallel to the long axis of the body, just on the inner side of the intestinal trunks; but in *Calicotyle*, *Monoctyle*, *Tristomum*, *Epibolella*, and *Diecidophora* the ducts of both sides are situated on the same straight line, which is directed at a right angle to the long axis of the body. In *Acine aberrans* and in *Octocotyle* the paired ducts unite with each other in the median line of the body immediately after leaving the vitellarium, and form the single yolk-duct (Pl. VII, fig. 5). In *Tristomum*, *Calicotyle*, and *Monoctyle* the paired yolk-duct of each side is again formed by the union of two smaller ducts which come respectively from the anterior and posterior part of the vitellarium; sometimes, however, it is formed by the simultaneous union of numerous ducts, as in *Trist. orale* (Pl. XXIII, fig. 1). In *Microcotyle truncata* the paired yolk-ducts appear to unite with each other at the very beginning and then to separate again into two ducts similar to those of the other species (Pl. II, fig. 1);

this, however, I conceive to be due not to the actual union of the yolk-duets, but to the circumstance that the paired portion of the vagina is exceedingly short. The paired duets of the two sides finally unite with each other, in most species in the median line of the body; but in *Dictyllophora sessilis* the point of union is displaced a little towards the right side. In all the species the paired yolk-duets form by their union an enlargement, which during the period of reproductive activity is usually swollen to a considerable size by the great quantity of yolk-cells which it contains, and has received the name of *vitelline reservoir*. In most genera this portion passes without any marked constriction into the contiguous parts; but in *Epibdella* and *Tristomum* it is usually spherical in form and is distinctly set off from the other parts. In *Ouchocotyle* and *Hexacotyle* also, it passes without any distinct demarcation into the anterior part of the yolk-duets, but is distinctly set off from the unpaired yolk-duets to which it gives rise (Pl. XV, fig. 1). The vitelline reservoir must not be regarded as a permanent organ, being observable only when it is filled with yolk-cells.

From the yolk-reservoir proceeds the unpaired yolk-duct. This is usually much smaller than the terminal portions of the paired duets, and is therefore distinctly marked off from the reservoir. In most species it either takes its rise on the ventral side of the reservoir or proceeds from it directly backwards, and after a course of various length according to the species finally opens into the oviduct. In *Hexacotyle*, however, it proceeds laterally from the reservoir and unites with the oviduct. In *Calicotyle* the unpaired yolk-duct is exceedingly short, and in *Monocotyle* it is entirely wanting, the paired duets opening in this genus separately into the oviduct from either side.

Where the various genital duets come to lie in the same sagittal plane, the yolk-duct is generally situated ventrally to them, but in *Calicotyle*, in which it opens into the seminal receptacle,

it occupies a position dorsal to the vagina.

The wall of the larger yolk-ducts, like that of the primary ones, consists of a thin structureless membrane wholly destitute of nuclei.

VAGINA—The vagina is very generally present in the monogenetic Trematodes; so far as I have observed it is wanting only in *Octocotyle* and *Dictidophora*. Dieckhoff<sup>1)</sup> indeed describes it in *Octobothrium lauceolatum*; but from his general description of this species and especially from the structure of the posterior suckers and of the genital organs as described by the same writer, I doubt whether this species is to be included in either of the two above mentioned genera as I shall define them in the systematic part of the present paper. The vagina is paired either throughout its whole extent, or in only its proximal part, or again it may be truly unpaired; in most species it opens by its proximal end into the yolk-duct. In *Monocotyle*, however, it opens directly into the oviduct at the same level, and side by side, with the paired yolk-ducts, so that in this genus three separate ducts come to open at the same point into the oviduct. In *Calicotyle*, again, the paired vaginal canals<sup>2)</sup> unite with each other in the median line of the body, and form a short unpaired duct which then opens into the *receptaculum seminis* (which is in this species nothing else than an enlarged portion of the oviduct) at a very short distance from the opening of the unpaired yolk-duct.

Having thus given a general orientation I shall now proceed to describe the vagina in different species.

As I have already stated elsewhere,<sup>3)</sup> a truly paired vagina is present in *Calicotyle* and *Ouchocotyle*. In the latter genus the vaginal openings lie on the ventral side of the body near the median line only

1). Dieckhoff—Beiträge zur Kenntniss der ectoparasitischen Trematoden. Archiv f. Naturgeschichte, 57. Jahrg., 1. Bd., 1891. p. 264.

2). By "vaginal canal" I mean the canal into which the vaginal opening leads.

3). Centralblatt für Bakteriöl. u. Parasitenkunde, Bd. XIV, 1893. p. 798.

a few sections (each = 0.01 mm.) behind, and on either side of, the genital pore (Pl. XV, fig. 1). The opening is wholly naked, and leads into a long canal, the vaginal canal, which proceeds just on the inner side of, and parallel to, the intestinal trunk, and finally opens into the fore end of the paired yolk-ducts. The vaginal canals are at first nearly of a uniform calibre, but very gradually become larger as they approach the yolk-ducts. In *Calicotyle* the vaginal openings lie nearly midway between the median line and the lateral margins of the body, nearly on the same level with the middle of the uterus. The vaginal canals, the terminal halves of which have a smaller calibre than the others, proceed at right angles to the long axis of the body towards the median line, where they unite with each other, and form a single duct, which then opens into the seminal receptacle from the antero-dorsal side (Pl. XIX, fig. 1).

In all the species of *Microcotyle* and *Aeine* I have examined, the vaginal opening is single, and is situated in the median line on the dorsal side of the body. In most species of *Microcotyle* the vagina is wholly naked, but in *Mic. reticulata* (Pl. V, fig. 5) and in *Aeine heterocerca* and *A. aberrans* (Pl. VII, figs. 5 & 6; Pl. VIII, fig. 4) its cavity is armed with numerous, conical, chitinous spines, which are seen in sections to be formed by simple elevations and transformation of the direct continuation of the investing membrane of the body (Pl. V, fig. 5; Pl. VIII, fig. 4). Moreover in all these species the mesenchyma around the vagina is modified into a very compact connective tissue consisting of closely reticulated fibres, the interspaces of which are filled with an exceedingly refractive substance, which remains wholly unstained either with borax-carmin or haematoxylin (Pl. V, fig. 5; Pl. VII, fig. 5; Pl. VIII, fig. 4). Again, in most species of *Microcotyle* the vaginal opening leads into a single median canal of different length according to the species, which usually proceeds straight back-

wards, but sometimes makes more or less windings (Pl. II, fig. 5). In *M. fusiformis* (Pl. II, fig. 3) the vagina is but slightly enlarged, but in *M. truncata* it assumes the shape of a goblet with its short neck directed towards the front end of the body (Pl. II, fig. 1). In the latter species it communicates by an exceedingly short, paired canal with either of the paired yolk-ducts; while in most other species the single vaginal canal proceeds backward for a greater or less distance along the median line of the body, and then divides right and left into two branches, the paired vaginal canals, which finally open each into the paired yolk-duct of the corresponding side, just as in *Onchocotyle*. In *M. sciencii* the vagina immediately divides into two canals, which, after proceeding backwards for a short distance, unite with each other in the median line of the body between the vas deferens on the dorsal and the uterus on the ventral side, then again separate from each other, and proceed backwards for a short distance, and finally open into the paired yolk-ducts (Pl. II, fig. 6). In *Axine heterocerca* also, the vagina divides immediately into the paired canals; but in this species these remain separate throughout their whole lengths, and proceeding backwards just on the inner side of the main trunks of the intestine, finally become continuous with the yolk-ducts<sup>1)</sup> (Pl. VII, fig. 1). There is in this species another opening a little behind the vagina (Pl. VIII, fig. 3, *x*), which leads into a blind cavity, the internal surface of which is armed with low, conical spines like those of the vagina; but although I have directed special attention to the point I have not been able to observe any connection with the genital organs, and am perfectly at a loss what function to attribute to it. In *Axine aberrans* the vaginal canal is single throughout its extent, and opens into the fore end of the unpaired yolk-ducts. In *Axine*

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1). The boundary between the vaginal canal and the yolk-duct is marked in the figure with an asterisk.

*triangularis* I have not been able to observe the vagina, since I had only a single specimen of this species ; but its presence is scarcely to be doubted.

In *Hexactyle* also, the vagina opens to the exterior on the dorsal side of the body in the median line, a short distance behind the common genital pore on the ventral side (Pl. XIII, figs. 1 & 4; Pl. XII, fig. 6); and its internal surface is armed with numerous chitinous, conical teeth similar to those of *Acine* (Pl. XII, fig. 6; Pl. XIV, fig. 3). The connective tissue around it presents a very different aspect from that of the remaining parts of the body, and is exceedingly compact and refractive. It is somewhat yellowish in the fresh state, and remains totally unstained with carmin or haematoxylin. In fact it is of the same nature as the tissue that surrounds the vagina in *Acine* and the terminal portion of the vas deferens in *Microtyle reticulata* and *Ouchocotyle*; but it is far more compact, so that it appears as if it were somewhat chitinous. In the genus under consideration the vagina is surrounded by numerous, circular muscular fibres; moreover from the chitinous cuticle that lines its cavity numerous muscular fibres take rise and radiating in all directions and ramifying each into a number of fibres, are at last inserted into the investing membrane of the body (Pl. XIV, fig. 3). These muscular fibres are evidently the *retractores vaginae*. The vagina soon divides into two canals, the *canales vaginales*, which, as in the cases already described, proceed on the inner side of, and parallel to, the trunks of the intestine, and open into the paired yolk-ducts. In accordance with the asymmetry in this genus of the yolk-ducts of the two sides, already mentioned, the vaginal canal of the left side is longer than that of the right (Pl. XIII, figs. 1 & 4; Pl. XIV, figs. 1 & 7).

From the above description the paired origin of the vagina in *Microcotyle*, *Acine*, and *Hexacotyle* is, I believe, beyond question.



In *Monocotyle*, *Tristomum*, and *Epibidella* the vagina is present only on the left side of the body, and opens to the exterior on the ventral surface. In *Monocotyle* the vaginal opening is situated close to the left trunk of the intestine, about midway between the *porus genitalis communis* and the anterior end of the ovary, and is surrounded by a compact tissue exactly similar to that described in *Heracotyle*; but there are no muscular fibres (Pl. XVII, fig. 1). It leads into a short canal which soon opens into a large spherical cavity, the *receptaculum seminis*; from the other end of this a canal proceeds backwards, and opens into the oviduct at the point where the latter receives the paired yolk-ducts. In *Tristomum* the vaginal opening is situated a short distance behind the opening of the genital atrium, in some species more towards the lateral margin, but in others nearer the middle line. In most species the opening is surrounded more or less with the compact tissue so often mentioned in other genera; but this is in most species very inconspicuous. The vaginal canal makes in this genus numerous complicated windings in its course; and at various distances from the external opening according to the species it is swollen to a considerable size and is filled with sperm mass—forming the *receptaculum seminis*. Beyond this the vaginal canal contracts into a very fine canal, which then opens in all the species I have observed into the yolk reservoir (Pl. XXI, fig. 8; Pl. XXII, fig. 5; Pl. XXIII, fig. 8; Pl. XXV, figs. 3, 8, & 8), and not into the oviduct as is stated by Monticelli<sup>1)</sup> to be the case in *Trist. uncinatum*.

From the above it is evident that the seminal receptacle in *Tristomum* and *Monocotyle* is nothing else than a part of the vaginal

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1). Monticelli—*Tristomum uncinatum*, n. sp. Boll. d. Soc. di Nat. in Napoli. An. III, fasc. II, 1889.

canal swollen by the sperm mass which it contains; and is therefore subject to considerable variations in size.

In *Epibolella* the position of the external opening of the vagina is very similar to that in *Tristomum*; in *E. Ishikarae* it is only a short distance behind the common genital pore, but in *E. orata* it is situated about midway between the posterior end of the pharynx and the anterior end of the ovary, a little internally to the left intestinal trunk, and is surrounded by the compact, refractive tissue already mentioned in describing other genera (Pl. XXVII, figs. 1, 3, 4, & 6). In *E. Ishikarae* the vaginal canal makes numerous windings in its course, and finally opens into the yolk-reservoir; but in *E. orata* it is nearly straight, and after a short course opens into the yolk-reservoir as in the other species. In this genus I have not observed any *receptaculum seminis*, but this may possibly be owing to the absence of any sperm mass at the particular time or in the particular specimens I have examined. Von Linstow<sup>1)</sup> does not mention any vagina in *Phylline Hendorffii*, but what he describes as the *receptaculum seminis* is probably nothing else than the proximal end of the vaginal canal, comparable to the seminal receptacle of *Tristomum*. In *Phyllonella soleae* also, the vagina has not been described; but to judge from the figure of the worm given by Cunningham,<sup>2)</sup> I believe it is present likewise in this species. The convoluted dark tube drawn by that writer on the left side (right side of figure) of the yolk-reservoir in fact represents, in my opinion, the proximal portion of the vaginal canal.

The wall of the vaginal canal consists in most species of a thin, refractive membrane similar to that of the larger yolk-ducts; and I have never observed any nuclei in it. In *Calicotyle*, however, the

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1). V. Linstow—Beitrag zur Anatomie von *Phylline Hendorffii*. Archiv f. mik. Anatomie, Bd. 33, 1889, p. 173.

2). J. T. Cunningham—A Treatise on the Common Sole, 1890, p. 93.

membranous wall is exceedingly thick, and its internal surface is uniformly covered with stout cilia. The terminal half of the vaginal canal is, in this genus, surrounded by numerous unicellular glands, the vaginal glands. Since I had only a single specimen of the worm and was therefore compelled to pass and re-pass it through absolute alcohol, clove oil, and turpentine in order to cut it into serial sections after a detailed examination *in toto*, I am not able to state anything definite as to the histological character of these glands; but each gland is a goblet-shaped cell with a short neck and with a vesicular nucleus near its larger end, which usually encloses a single, small nucleolus (Pl. XIX, figs. 1 & 12). These glandular cells are in most places arranged in a single layer around the vaginal canal, but are in other places also arranged in two layers. Wierzejski<sup>1)</sup> states that in *C. Kroyeri* the vaginal canal is muscular, but in the species I have observed its wall is simply membranous. In *Onchocotyle* also the internal surface of the vaginal canal is covered with cilia, which are, however, finer and shorter than those of *Calicotyle* (Pl. XV, fig. 10). I have besides observed in the former species that in the hinder portion there is often on the inner surface of the vaginal canal a thin layer of granular substance very similar to that observed in the vas deferens. I have therefore been led to suspect whether the irregular polygonal or goblet-shaped cells drawn in fig. 8, Pl. XVI, on the ventral side of the vaginal canal and which were at first regarded by me as the prostate glands be not in reality the vaginal glands; but hitherto I have not been able to find out any ducts. In all the other species I have not observed any glandular cells around the vagina.

In many specimens collected during the summer season the vagina was found filled with spermatozoa. I have observed this in *Microcotyle*, *Axine*, and *Tristomum*; and since, as I have said in my

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1). Wierzejski—*l. c.* p. 558.

paper on *Diplozoon*, the yolk-cells are during this season almost continuously poured *down* the yolk-ducts, the spermatozoa in the vagina can not but have come from another individual. Often indeed the yolk-ducts were also filled entirely with spermatozoa instead of with yolk-cells. Therefore there can scarcely be any doubt that the vagina really serves as such in these forms, and the same is in all probability true of other species.

CANALIS GENITO-INTESTINALIS—I have proposed<sup>1)</sup> to substitute this name for the one already in vogue, *canalis vitello-intestinalis*, on the ground that in many, indeed in most, species it has no direct connection with the yolk-duct. This name, which was first used by the editor of the "American Naturalist",<sup>2)</sup> is of wider application and will cover all those cases which may be brought to light by future investigations, provided only that the canal connects the intestine with any one part of the genital system. The genito-intestinal canal was first observed in its true relation by Ijima<sup>3)</sup> and although the connection with the intestine was denied or questioned by some writers his observation was afterwards confirmed and extended by Dieckhoff,<sup>4)</sup> R. Wright and Macallum<sup>5)</sup> and by the present writer,<sup>6)</sup> and in this paper further cases will be brought forward.

Among the genera described in this paper this canal is absent in *Tristomum*, *Epibolella*, *Monocotyle*, and *Calicotyle*, but is present in all

1). Goto—Der Laurer'sche Kanal und die Scheide. Centralblatt f. Bakteriöl. u. Parasitenkunde, Bd. XIV, 1893. p. 793.

2). Vol. XXV, 1891. p. 665.

3). Ijima—Ueber den Zusammenhang des Eileiters mit dem Verdauungseanal bei gewissen Polystomeen. Zool. Anzeig., VII, 1884. p. 635.

4). Dieckhoff—*l. c.*

5). R. Wright and Macallum—Sphyrnura Osleri. Journal of Morphology, Vol. 1, 1887.

6). Goto—This Journal, Vol. IV, 1890. p. 185.

„ —On the Connecting Canal between the Oviduct and the Intestine in some Monogen. Trematodes. Zoolog. Anzeig., XIV, 1891. p. 103.

the others. In *Microcotyle* and *Acine* it arises from the oviduct opposite, or at a short distance from, the point where this receives the unpaired yolk-duct, in some species more towards the ovary and in others more away from it; it then proceeds toward the right of the body and also more or less forwards, and finally opens into the right trunk of the intestine. In *Diclidophora* (Pl. X, figs. 1, 5, & 9) it does nearly the same, but its origin is always at a short distance towards the ovary from the point of union of the unpaired yolk-duct with the oviduct. In *Octocotyle* the genito-intestinal canal opens into the oviduct side by side with the unpaired yolk-duct, proceeds on the right side far towards the anterior part of the body, and finally opens into the right intestinal trunk nearly on the same level with the point of union of the paired yolk-ducts (Pl. IX, figs. 1, 7, & 11). In all the genera hitherto mentioned the canal is almost straight or makes only a slight winding or two. In *Onchocotyle* it arises from the oviduct at the point where this bends backwards towards the ootyp and where from one side the neck of the seminal receptacle and from the other the median yolk-duct opens into the oviduct. It then proceeds for some distance towards the right side of the body, then bends backwards, making a few additional windings on the way, and opens at last into the intestinal trunk of the right side. It is, as I have stated elsewhere, the Laurer's canal of Taschenberg,<sup>1)</sup> which he represents as being on the left side of the body and as opening to the exterior on the ventral surface. But I have carefully followed it in serial sections and could distinctly perceive its opening into the intestine; while as to its position in the body, one must not rely on the posterior suckers for orientation, in this case; for, as I have already stated, these are situat-

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1). Taschenberg—Weitere Beiträge, p. 22.

ed on the side turned towards the dorsum, so that when the observer looks at the worm with the suckers turned towards him he has before him the dorsal side of the body, whereas in other species the ventral side would under the same circumstance be turned towards him. I therefore believe that Taschenberg was misled in his orientation by the abnormal position of the suckers, and this is the more probable because he seems to have had but little recourse to serial sections.

In *Hexacotyle grossa* the origin of the genito-intestinal canal from the oviduct is also near the opening of the yolk-duct a little towards the ovary. Proceeding a very short distance forwards it undergoes a rather sudden and somewhat club-shaped enlargement which, since it contains sperm mass in its interior, may well be called *receptaculum seminis*. From its opposite end arises a much convoluted small canal, which proceeds forwards and towards the right side of the body, and finally opens into the intestine (Pl. XIV, fig. 7). In *Hexacotyle acuta* the genito-intestinal canal opens into the oviduct side by side with the unpaired yolk-duct, and, in most specimens, was soon enlarged into the *receptaculum seminis*, so that the latter was connected with the oviduct by an exceedingly short canal. The general form of the seminal receptacle in this species is similar to that of the other species, but its outline is in most cases irregularly wavy, and the whole organ usually assumes such a position that its long axis is directed obliquely to the long axis of the body. The anterior end of the seminal receptacle gives rise to a small canal of variable length, which, proceeding a little forwards when the receptacle is small or a little backwards when it is large, and making some convolutions on the way, finally opens into the intestine (Pl. XIV, fig. 4). In both species of *Hexacotyle* the seminal receptacle is situated on the ventral side of the ovary.

From the above description it will be evident that the *receptaculum*

*seminis* of *Hexacotyle* is nothing but a part of the genito-intestinal canal, just as in *Tristomum* it is a part of the vaginal canal. The smallness of the seminal receptacle and the greater length of the canal proceeding from it towards the intestine observed in *Hexacotyle grossa* as compared with *H. acuta* is perhaps due to the fact that the sperm mass was comparatively small in the specimens of the former examined; for in *H. acuta* I have observed the seminal receptacle to vary considerably in size, and the small canal to vary in length; the size of the receptacle and the length of the canal being complementary, the receptacle being formed inferentially, at the expense of the canal. The fact already mentioned that in *H. acuta* the small canal proceeds from the seminal receptacle sometimes in one direction and sometimes in the other also points to the same interdependence; the cramming of the receptacle with sperm mass and its consequent lengthening causing displacement of the genito-intestinal canal.

The wall of the *canalis genito-intestinalis* is formed of a thin, structureless membrane, whose inner surface is uniformly covered with fine cilia, the motion of which is distinctly observable in living specimens under the microscope. It is wholly destitute of nuclei. In *Microcotyle* and *Axine* the wall is thickened circularly at short intervals just like the wall of the Laurer's canal in some species of *Distomum* described by Poirier;<sup>1)</sup> only the thickenings are here much smaller and nearer one another. In oblique or longitudinal sections of the canal these thickenings look somewhat like septa, but that they are not really such is very clear on attentive observation. In a surface view these thickenings appear like circular muscular fibres.

As to the opening of the canal into the intestine, it is to be noted that it is exceedingly small and in most cases never appears in more

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1). Poirier—*l. c.*, p. 577.

than two consecutive sections (each = 0.01 mm). Dieckhoff<sup>1)</sup> has described in *Polystomum integerrimum* a sort of valvular mechanism at the opening of the canal; I have not myself observed the canal running any distance into the intestine, but have found it always to contract to an exceedingly small size just before opening, and to communicate with the intestine by a minute pore which will be at once closed by pressure from within the intestine.

The homology of the genito-intestinal canal will be discussed later on under 'General Considerations.'

ATRIUM GENITALE—I shall adopt this name for the cavity into which, in many genera, the vas deferens and the uterus, or else the former alone, open, whether this cavity be large and open to the exterior by a small pore, or merely a shallow invagination of the general surface of the body. This cavity has been more generally known as the genital cloaca; but since the vas deferens only in some cases opens into it I prefer the above name for it. It is very generally present not only in the Monogenea but also in the distomes; and in some cases what has been described as the penis or "Cirrusbeutel" (tasca del pene, poche de cirrhe) is to be called more correctly the genital atrium, as will become clear as we proceed.

Among the species that I have hitherto examined the genital atrium is absent only in *Onchocotyle spinacis*, in which the vas deferens opens, as already stated, directly into the terminal part of the uterus (Pl. XVI, fig. 7). This part might perhaps be considered by some as the genital atrium; but as may be seen from the figure just referred to, its internal surface is covered up to its very opening with stout cilia exactly similar to those of the part of the uterus posterior to it; and this fact should prove beyond doubt that the genital atrium is totally wanting in this species. Moreover it seems to me that the

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1). Dieckhoff—*l. c.* p. 248.



genital atrium should be regarded as the invagination of a portion of the surface of the body. We have as yet no adequate embryological proof<sup>1)</sup> on this point; but the fact that the investing membrane of the body is in many cases directly continued, at least for a certain distance, into the atrium, and the many gradations in form of this chamber from that of a mere pit to that of a deep and spacious cavity seem to me to lend very strong support to this view—a view which has recently found expression from another side<sup>2)</sup>

The genital atrium is most developed and presents the most varied forms in *Microcotyle*. In this genus it is a deep cave-like cavity, into which the vas deferens and the uterus open, and communicates with the exterior by means of a minute opening, the *porus genitalis communis*. Its inner surface is lined by a thin but deeply staining membrane which in sections is seen to be formed by the direct continuation and gradual thinning of the investing membrane of the body (Pls. V, & VI), and is covered in all the species with hollow, chitinous spines. In *M. elegans* (Pl. V, fig. 2.) it is a somewhat reniform cavity, with the part corresponding to the hilus directed obliquely forwards and towards the ventral side, into which the uterus opens close to the external pore, while the vas deferens opens more on the dorsal side almost opposite the hilus. The conical spines which are mainly confined to

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1). The results obtained by Voeltzkow in *Aspidogaster conchicola* (Würzburger Arbeiten, Bd. 8, 1833, p. 279) do not seem to me to decide the question. According to this naturalist the "Penisschlauch" and the "Vulva" arise "als solider, von der Haut am Anfang des Halses, schief nach hinten und oben aufsteigender.....Zapfen an." Referring to the figure it seems to me that the solid mass of cells which becomes afterwards the "Penisschlauch" and the "Vulva" is not of an ectodermal origin but mesodermal; for the true ectoderm is already in this stage transformed into a membrane. If I may put my own interpretation on the figure of another, the solid mass of cells above referred to is probably differentiated into the peculiar connective tissue that constitutes the penis; and in this case the lining of the "Penisschlauch" would alone be derived from the ectoderm.

2). Monticelli—Primo contributo di osservazioni sui Distomidi (Studi sui Trematodi endoparassiti), p. 86. Spengel's Zool. Jahrbücher, III. Suppl., 1893.

the anterior half of the atrium are comparatively short. I have observed only a few spines on the posterior face of the atrium between the uterus and the vas deferens; and these were mostly a little longer than those of the anterior and dorsal sides. In *M. fusiformis* (Pl. V, fig. 1) the genital atrium is considerably elongated in the dorso-ventral direction of the body and may be distinguished into two portions, a ventral, larger portion communicating with the exterior and a dorsal, narrower portion. The larger, ventral portion receives close to its opening the uterus and at its dorsal end the vas deferens. The narrower, dorsal portion merely extends dorsad towards the oesophagus and there ends blindly, receiving no duct. The spines which are generally just perceptibly shorter than those of *M. elegans* are mostly confined to the anterior face of the atrium but are also present on the posterior face for a very short distance continuous with the anterior face. The wall of the atrium is raised a little around the vas deferens, making it open on a blunt papilla (Pl. V, fig. 1). In *M. caudata* (Pl. V, fig. 3) again, the genital atrium may be distinguished into two portions, a ventral which in this case is narrower, and a dorsal portion which is triangular in sagittal section and whose surface is covered with long, slightly recurved spines. The ventral portion receives, as in other species, the uterus near its external opening; and at its postero-dorsal corner it communicates with a cup-shaped accessory cavity, into which the vas deferens opens at the top of a comparatively large, teat-shaped papilla. In *M. sebastis* (Pl. VI, fig. 1) the main cavity of the genital atrium proceeds obliquely forwards from its external opening, and ends with a short bifurcation, so that it is somewhat Y-shaped. The spines are long and slightly recurved, and are present along the whole anterior and dorsal surfaces of the atrium; but these are divided into two groups separated from each other by a short space, in which the spines are totally absent. As in the preceding species the vas

deferens opens at the top of a papilla, which however is of the shape of a truncated cone in this case, and projects into a cup-shaped accessory cavity of the genital atrium. In some specimens I have observed a layer of coarsely granular substance covering the internal surface of the vas deferens as well as the surface of the truncate papilla, and of the cavity into which it projects; this is, in my opinion, the secretory product of the prostate glands. In *M. chiri* (Pl. V, fig. 4) the genital atrium is very narrow and is elongated in the dorso-ventral direction of the body, and the uterus and vas deferens open into it close to each other. Its internal surface is lined by an exceedingly thin membrane, and the spines, which are very similar to those already described as being present in the terminal part of the vas deferens in *M. reticulata*, are in this species attached to the internal face of a cup-shaped organ at the dorsal end of the atrium, which will be described afterwards. In *M. sciencu*, again, the genital atrium is an elongated cavity directed obliquely in an antero-posterior direction and opening outwards by means of a very small pore (Pl. VI, fig. 2). The chitinous spines are of two forms, the shorter and the longer, arranged in two circular sets around the middle portion of the atrium; the shorter ones, which are hook-shaped, being imbedded for the greater part of their lengths in the substance of the wall of the cylindrical organ afterwards to be described, with only their hooked ends projecting into the atrium. The spines of the other set are much longer, and are slightly curved twice in opposite directions; only their terminal parts project into the atrium, and they are provided with a special set of muscular fibres, probably to be regarded as belonging to the sets of dorso-ventral fibres which take their origin from them and which, proceeding backwards and towards the dorsum are inserted into the investing membrane on the dorsal side of the body (Pl. VI, fig. 2). The uterus opens into the atrium near

its external pore, while the vas deferens opens between the two sets of chitinous armature just described.

Owing to scantiness of specimens I have not been able to make sagittal sections of *M. truncata* and *M. reticulata*; but comparing the preparations *in toto* of these species with those of others, the presence of the genital atrium can hardly be doubted, and the general disposition of its parts is, I believe, similar to that found in other species. In *M. truncata* the chitinous armature of the atrium consists of twenty long, hollow rods, slightly curved twice in opposite directions (Pl. II, fig. 2). They are elliptical in cross-section (fig. 2, *c*), and although on a surface view they appeared of unequal lengths, as represented in the figure, I believe this is owing to the fact that some were looked at more obliquely than others. They are arranged in a circle, but the series is broken in the median line on the dorsal side.

The genital atrium of *M. reticulata* and *Axine aberrans* are very similar to each other, the internal surface being in both the species covered with spines, and the mesenchyma around the atrium being transformed into the refractive connective tissue so often mentioned already. The form of the spines are, however, different in the two species, those of *A. aberrans* being simply conical and slightly curved, while those of *M. reticulata* are exactly similar to those that are present in the terminal portion of its vas deferens, and consists, as already described, of a hemispherical basal and a straight, spinous, distal portion (Pl. V, fig. 6). In *Axine heterocerca* the genital atrium is an irregular, tolerably spacious cavity, and is surrounded by a refractive, fibrous connective tissue somewhat similar to that just mentioned in *M. reticulata*. Unlike that, however, it stains but slightly (Pl. VIII, fig. 3), and in fact its occurrence here appears to me as a step towards the formation from the usual form of the mesenchyma of such refractive tissue as has been described above in

many species of *Microcotyle*. Of *Axine triangularis* (Pl. VII, fig. 7) I have had only a single specimen, and therefore could not make sagittal sections of it; but judging from analogy and from a comparison of preparations of it *in toto* with those of others, I believe the genital atrium of this species to be very nearly similar to that of *M. chiri* already described (Pl. V, fig. 4). There is a hemispherical organ on the dorsal side of the atrium exactly similar in form to that of *M. chiri*, and the internal surface of which is covered with slightly recurved, conical spines (Pl. VII, figs. 7 & 8). I have not been able to see distinctly the opening of the vas deferens; but I believe it lies as in *M. chiri*, and not therefore in the hemispherical organ—again relying in so doing on analogy.

In *Octocotyle* the genital atrium is somewhat vase-shaped, with a short narrow neck which opens to the exterior. It receives at one of its sides the uterus, and the chitinous spines of the penis project from the base of its cavity (Pl. IX, fig. 12). In *Declidophora*, on the other hand, the genital atrium has a wide opening to the exterior, almost of an equal diameter with the atrium itself (Pl. XI, fig. 4). It sends out backwards a tubular prolongation which becomes continuous with the uterus, the boundary line between the two being in this case especially hard to determine. On the dorsal side, the main cavity of the atrium communicates by means of a minute pore with a somewhat cone-shaped side-cavity, into which the chitinous hooks of the penis project (Pl. XI, fig. 4). In *Hexacotyle* the genital atrium communicates with the exterior by means of a short, tubular canal formed by the thickening of the lips of its external opening (Pl. XII, fig. 6). As a whole it is a tolerably spacious cavity; but all its central part is occupied by a large conical papilla—the homologue of the penis—on the top of which opens the vas deferens. In this genus the direct continuation of the external investing membrane of the body into the genital atrium can be observed

very distinctly (Pl. XII, fig. 6); and on the posterior surface of the penis the membrane seems to be changed to a certain extent into a chitinous nature; for here it remains wholly unstained with haematoxylin and has all the optical properties of a chitinous substance. In *Calicotyle* (Pl. XIX, fig. 7) the *atrium genitale* is reduced to a very small cavity communicating with the exterior by a comparatively large pore, and the greater part of it forms merely a sheath for the exceedingly long, chitinous penis already described. In *Monocotyle* it is more spacious and opens to the exterior by a somewhat small pore; but the greater part of its cavity is almost completely taken up by the penis (Pl. XVIII, fig. 3). The external membrane of the body is also in this case clearly seen to be continued into the genital atrium; here, however, it becomes very much thinner and compact, and loses its granular character.

In all the species hitherto considered the genital atrium receives both the vas deferens and the uterus, so that it may without any impropriety be called the genital cloaca; but this is not the case in some species of the next genus as will presently be seen.

In *Tristomum* as well as in *Epibdella* the genital atrium is an elongated, more or less tubular cavity with a very small external opening. Into it the penis projects; and in most species the uterus opens into it, but in some species, as in *T. rotundum* and *T. ovale*, this opens independently to the exterior, so that the cavity can not be called the genital cloaca. In *Epibdella orata* it is for the greater part of its length tubular, but is enlarged towards its ends to make room for the penis (Pl. XXVI, fig. 6). The uterus opens into it between the tubular and the enlarged portion. In *E. Ishikawae* the whole atrium is more or less tubular in accordance with the greater length of the penis; and the uterus opens on the top of a low, conical papilla, a short distance behind the middle of the length of

the atrium; so that here the atrium is locally enlarged and sends out a lateral evagination on one side (Pl. XXVI, fig. 3). In both the species of *Epibhellu* above mentioned the genital atrium extends up to the very base of the penis, so that this projects wholly into it. In *Tristomum*, on the other hand, the basal portion of the penis lies imbedded in the mesenchyma, so that the genital atrium forms a sheath only for the terminal portion of the penis. Its form is very varied in different species; but always consists of a more or less tubular distal portion of various length and a more enlarged proximal portion forming the sheath for the penis. The internal surface is lined by a thin membrane, which is the direct continuation of the external membrane of the body on one side and of the investing membrane of the penis on the other. Where the uterus opens into the genital atrium, its opening lies at various distances from the external atrial pore in different species, being in some situated close to it, while in others it is far removed towards the bottom of the atrium (Pl. XXI, fig. 8; Pl. XXII, figs. 2 & 4; Pl. XXIII, fig. 8; Pl. XXV, figs. 3, 8, & 9).

The genital atrium of *Tristomum* and *Epibhellu* is wholly destitute of any chitinous armature.

In most species of *Axine* and *Microcotyle* the conical spines that arm the genital atrium are distinctly seen to be formed by the elevation and transformation of the lining membrane (Pl. V, fig. 3; Pl. VI, fig. 1; also in figs. 1 & 2, Pl. V, though not clearly shown in the figures). These spines are, as already stated, hollow, and the internal cavity is filled in most species with a deeply staining, homogeneous substance which is directly continuous with the basement membrane and is indistinguishable from it by optical characters. In *M. chiri* (Pl. V, fig. 4), *M. reticulata* (Pl. V, fig. 6), and *M. sciaenae* (Pl. VI, fig. 2) the cavity in the spines is reduced to very small dimensions

appearing only as a dark line in optic sections, and is closed towards the base of the spines. In these species the spines either merely rest on the lining membrane or are imbedded in the connective tissue. In *M. chiri* the spines rest on the internal surface of the hemispherical organ already referred to, and lie mostly imbedded in the mesenchyma, with only their tips projecting into the genital atrium.

Let us now turn our attention to the mass of connective tissue of peculiar appearance so often referred to already, which is present in many species around the genital atrium, and which extends in some species for a certain distance around the vas deferens.

In *Microcotyle caudata* (Pl. V, fig. 3) and *M. fusiformis* (Pl. V, fig. 1) the mesenchyma on the antero-dorsal side of the genital atrium presents an unusual appearance, and consists of compact, fibrous connective tissue wholly destitute of nuclei, although these are very numerous around it in *M. caudata*. In *M. fusiformis* this mass of connective tissue is of spherical form, and seems but little different from the tissue around, the difference lying mainly in its greater compactness; but in *M. caudata* its meshes are filled with a refractive, granular substance, somewhat yellowish in the fresh state and more decidedly yellow after treatment with borax-carmin. The granulation diminishes towards the genital atrium, close to which it becomes exceedingly fine. In *M. elegans* (Pl. V, fig. 2) and *M. sebastis* (Pl. VI, fig. 1) there is a kidney-shaped mass of connective tissue wholly destitute of nuclei, and very refractive—the refraction being caused by a perfectly homogeneous substance filling the meshes of the connective tissue, the fibres of which are directly continuous with those of the surrounding mesenchyma. In *M. elegans* there are some coarse granulations close to the genital atrium at the place corresponding to the hilus of the kidney. In this species the kidney-shaped mass just described is pretty distinctly separated from the surrounding



tissue; while in *M. sebastis* the transition is more gradual. Moreover, in the latter species there are numerous large, vesicular nuclei close around the mass, each of which is surrounded by a sparse quantity of finely granular protoplasm gradually fading away towards the periphery, just as in *M. caudata*. In *M. chiri* (Pl. V, fig. 4) and *M. scienuae* (Pl. VI, fig. 2) there is at the dorsal end of the genital atrium a cup-shaped or bag-shaped organ, the wall of which is completely set off from the surrounding tissue by a membrane, and is composed of refractive, prismatic fibres exactly similar in optic properties to the fibres that have been described in the suckers of *Axiue*, *Microcotyle*, *Octocotyle*, and some other genera. In *M. chiri* this organ is, as already mentioned, hemispherical in shape, and is separated from the cavity of the genital atrium by a layer of connective tissue; moreover, the external limiting membrane of the organ reveals, on careful examination, on its outer side a transition of its substance into the fibrous connective tissue around. In *M. scienuae* it is cylindrical in shape, and appears U-shaped in longitudinal sections, and forms the wall of the posterior part of the genital atrium. For reasons already stated I am not able to make any definite statement on this head concerning *M. truncata* and *M. reticulata*; but the latter species seems to resemble closely *M. sebastis* in this respect; while in the former species the compact, refractive mass of connective tissue is more elongated in form. In *Axiue* the compact connective tissue already described around the terminal portion of the vas deferens is continued on around the genital atrium.

A genital atrium similar to those above described in most species of *Microcotyle* seems, to judge from the figures and description of Leuckart,<sup>1)</sup> to be present also in *Distomum heterophyes*. As in this endoparasite, so in *Microcotyle* I believe the genital atrium can be

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1). Leuckart—Die Parasiten des Menschen. 2. Aufl. p. 401 *et infra*.

evaginated, and the spines serve to assist the act of copulation.

After what have been said above I believe it is hardly necessary to point out that the description of the "Cirrus" by Lorenz<sup>1)</sup> in *Axine belones* seems to me not to correspond to the actual relation of things. I also venture to believe that what has been described by the same writer as the male genital opening in *Microcotyle moruyri* is in reality the opening of the genital atrium, and the assumed female pore to be the opening of the uterus not to the exterior but into the genital atrium.

The spines that are present on the internal surface of the genital atrium in *Microcotyle* and *Axine* I shall call *atrial spines* to distinguish them from the *penis spines* or *hooks* of *Octocotyle* and *Dictidophora* and from the tubular *chitinous penis* of *Calicotyle* and *Monocotyle*.

#### 10. General Considerations and Comparison of Results.

I shall now add, partly by way of recapitulation, some general considerations; and in the first place I shall discuss—

1. *The Nature of those prismatic, refractive Fibres which constitute the Wall of the Suckers of Axine, Microcotyle, Octocotyle, Dictidophora, Hexacotyle and Onchocotyle.* These fibres have been spoken of by most writers simply as muscular fibres; the only exception being, so far as I know, Wright and Macallum, who say,<sup>2)</sup> "Instead of the substance of the sucker being formed of muscular fibres disposed in three directions, and capable of modifying the shape of the cavity, as in the distomes, it is not possessed of contractility in *Sphyrarura* (and probably in *Polystomum*), and is formed of prismatic fibres, rather of a supportive than of a muscular character, arranged perpendicularly between the concave and convex limiting membranes of the sucker." My observa-

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1). Lorenz—*l. c.* pp. 11 & 25.

2). Wright & Macallum—*l. c.* p. 12.

tions have led me to the same conclusion. I have indeed no positive proof of the non-contractile nature of these fibres; but the indirect evidence which I shall here advance seems to me, when duly considered, too strong to be resisted.

In the first place, the fibres under question are different from the ordinary muscular fibres of the body and from those of the suckers of the *Tristomidæ* and the *Monocotylidæ*, as well as from those of the anterior sucker of *Onchocotyle*, both in optical characters and in reaction towards staining fluids. Thus, these fibres are in the fresh state slightly yellowish in colour and are less refractive than the muscular fibres; and while the latter stain with hæmatoxylin usually well, though not deeply, the former remain in most cases totally unstained. There are indeed cases, as in *Hexacotyle*, in which the fibres of the suckers stain slightly; but they then always stain more weakly than the muscular fibres. They seem also to have a greater affinity for colouring substances when the worm has been preserved some time after its death, and therefore presumably after some *post mortem* change has set in, as well as in those specimens which have been kept in alcohol for a long time<sup>1)</sup>. But in nearly all cases the differences in the two respects above specified—refrangibility and reaction towards colouring fluids—are enough to impress one with the idea that the fibres under question must be very different in their nature from the muscular fibres that are found in other parts of the body. For instance, a glance at fig. 4, Pl. XII, which represents as exactly as I could make it, a portion of the longitudinal section of a sucker of *Diclidophora*, will convince one of the difference at least in optical characters between the fibres that constitute the wall of the sucker and the muscular fibres that are attached to it. But in the second place we can trace all the various stages between these fibres and the ordinary connective tissue

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1). In the latter case all the tissues stain more diffusely than when new.

that constitute the mesenchyma of the body. In doing this, however, it will be necessary for us to widen our field of view and take into account the mass of peculiar connective tissue already described around the genital atrium of *Microcotyle*. Let us compare the suckers, both anterior and posterior, of *Microcotyle*, *Axine*, or any other of the genera mentioned at the beginning of this chapter, with the hemispherical or elongated sac-like organs which form the wall of the posterior or dorsal part of the genital atrium in *Microcotyle sciaenæ* and *M. chiri*, and we shall at once recognise that both are composed of fibres of the same nature—so exactly alike are they both in optical characters and in their reaction towards staining fluids. Now any one who cared to peruse the descriptions I have given above of this mass of peculiar connective tissue in different species of *Microcotyle*, and took the trouble of comparing the figures of it given in Pls. V & VI would at once see that it is in reality a specially differentiated portion of the general mesenchyma of the body. In *Microcotyle fusiformis* (Pl. V, fig. 1) and *M. caudata* (Pl. V, fig. 3) it is clearly seen to be nothing but a part of the mesenchyma, which has, however, assumed a somewhat different character from the surrounding portion; in *M. elegans* (Pl. V, fig. 2) and *M. sebastis* (Pl. VI, fig. 1) it is more clearly distinguishable from the surrounding part, but its origin is still unmistakable; and finally in *M. chiri* (Pl. V, fig. 4) and *M. sciaenæ* (Pl. VI, fig. 2) a limiting membrane has been developed around it and has distinctly separated it from the surrounding tissue. In *M. chiri*, however, the outer membrane is, as already mentioned, not so distinct from the surrounding mesenchyma as in *M. sciaenæ* and in the suckers of other species, but reveals a perceptible transition into it; the fibres of the mesenchyma passing into, and forming, the membrane. In this connection it should also be borne in mind that the wall of the small suckers at the apex of the caudal appendage in *Onchocotyle* is

formed of a connective tissue whose fibres are arranged mainly at right angles to the outer and inner limiting membranes. We have, therefore, an almost complete series of stages from the ordinary fibrous, reticulated connective tissue to the compact substance consisting of refractive, prismatic fibres, which constitutes the wall of the suckers of *Axine*, *Microcotyle*, *Otrocotyle*, *Dictilophora*, *Hexacotyle*, and *Onchocotyle*, (the anterior sucker excepted in the last genus) and the hemispherical or cylindrical organ around the genital atrium of some species of them. The prismatic fibres seem to be formed by a transformation of the granular substance usually present in the meshes of the connective tissue, while the connective tissue fibres themselves appear to remain mostly unchanged and are seen well stained in sections.

As I have said above, we have no positive proof that the prismatic fibres in question are non-contractile; but their genesis as above explained seems to me to exclude the view which regards them as of muscular nature.

If now the fibres that constitute the wall of the suckers of the genera above mentioned are non-contractile, the question arises how is the suctorial action to be explained. Lorenz<sup>1)</sup> indeed has denied such an action to the posterior organs of attachment of *Microcotyle* and *Axine*, and has called them simply "Haftorgane"; but that they are true suckers is beyond doubt; for I have observed living specimens of *Microcotyle* attach themselves to a glass slide by means of the posterior suckers. I have also observed them execute a leech-like locomotion by alternately attaching and detaching the anterior and posterior ends of the body; and I can not see how the worm can attach itself to a glass slide unless the action of these posterior organs of attachment be suctorial. The anterior suckers must also be able to exercise suction; for in *Microcotyle* there is no other organ at the anterior end of the body, by

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1). Lorenz—*l. c.*, p. 6.

means of which the worm can attach itself to foreign bodies sufficiently firmly as to drag its body after it. We are therefore compelled to admit the suctional action of both the anterior and the posterior suckers. This action I shall now proceed to explain.

The so-called chitinous rods and pieces that compose the supporting frame-work of the suckers are, as I have already stated, not formed by true chitin, but are soluble in caustic potash, and in some species stain more or less, and do not seem to be rigid. On the contrary, I believe they are easily flexible but elastic, so that when distorted by external force they constantly tend to resume their original form. In fact, if a living worm be observed under the microscope the suckers are seen to constantly change their form; and this seems to be impossible if the so-called chitinous frame-work be perfectly rigid. I also believe that the prismatic fibres which compose the wall of the suckers are likewise elastic; this seems to be very probable from their great (doubly?) refractive power and from their other optical characters. The image, then, I form of the suckers from the physiological point of view is that of a bag (hemispherical or rectangular) with a thick, elastic wall which constantly tends to be flattened out, but which is kept in proper shape by an external force, that of the muscular fibres that are attached to the bottom of the suckers. If these muscular fibres relax, the wall of the sucker becomes flattened out by virtue of its elasticity and applied to its substratum, the body-surface of the host; if now the muscular fibres contract, the sucker assumes the form of a bag, and thus a vacuum tends to form within, giving rise to a suctional action. In favour of this view it may be mentioned in addition that in many sections of the suckers the prismatic fibres are seen to be much pressed against one another at the inner side of the suckers near the point where the wall is folded on itself—the part where the fibres must necessarily be

exposed to strong mutual pressure (Pl. III, fig. 8; Pl. XV, fig. 8; Pl. IX, fig. 8). In this process the portions of the investing membrane of the inner surface of the suckers, which have in some species been chitinously changed, would materially assist the elasticity of the wall.

The bulbous penis of *Octocotyle*, *Diclidophora*, and *Calicotyle* are evidently composed of fibres the same in nature as those of the suckers of the first-named two genera, and therefore in my opinion not muscular.

If, again, my view as to the origin of the genital atrium be true, that it is formed by the invagination of the surface of the body, it unifies in an unexpected manner the relation of the suckers of the genera so often mentioned above to the hemispherical or cylindrical organs about the genital atrium in some species of *Microcotyle*, in being composed of exactly the same substance, for since, according to it both kinds of organs fall under the same category of local modifications for special purposes of the mesenchyma near the external surface of the body, they therefore consist of the same substance.

2. *Penis*.—After what I have said about the penis in different species and genera I believe that the relation of its different forms can be made out more satisfactorily than has hitherto been done.

The penis seems to have its most complicated structure in *Tristomum* and *Epibdeulla*. It is here, as already described, a hollow club-shaped organ projecting by its distal portion into the genital atrium with which its internal cavity is directly continuous, and is provided with muscular fibres of its own arranged in two ways, *viz.*, circularly and longitudinally. In my opinion, it is to be regarded as formed by an elevation of the wall of the genital atrium around the opening of the vas deferens and a simul-

taneous displacement of the latter from the base of the penis towards its top; so that the cavity of the penis is morphologically speaking as much the external surface of the body as the genital atrium, and the prostate glands are therefore to be regarded as a special modification of the dermal glands,—a view clearly in accordance with some facts observed in *Temnocephala*.<sup>1)</sup> The tissue of the large papilla projecting into the genital atrium at the top of which the vas deferens opens in *Hexacotyle* is not bounded off from the surrounding mesenchyma; but that it is the homologue of the penis will, I believe, scarcely be contested by any one. In *Monocotyle* (Pl. XVIII, fig. 3), on the other hand, the connective tissue that forms the substance of the penis has undergone some transformation, having become fibrous with the fibres arranged at right angles to the internal and external limiting membranes of the penis. It is, however, not yet distinctly separated from the surrounding mesenchyma by a membrane. The penis encloses, in this genus, a tubular, chitinous organ—the chitinous penis—which is attached to it at the bottom of its cavity, and into which the vas deferens opens. This chitinous penis is regarded by St.-Remy<sup>2)</sup> as the transformed terminal portion of the vas deferens. It seems to me, however, to be more in accordance with facts to regard it as the prolonged portion of the inner limiting membrane of the penis, which has then undergone a chitinous transformation; and as this limiting membrane is morphologically no other than a portion of the lining membrane of the genital atrium, which is again but the invaginated portion of the investing membrane of the body, the chitinous penis is, in my opinion, to

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1). Haswell—On *Temnocephala*, an Aberrant Monogenetic Trematode. Quart. Journ. of Mic. Sci., vol. 28, 1888. p. 288.

2). St.-Remy—*l. c.* p. 24.



be regarded as a chitinised portion of the investing membrane. This view will, as will be seen afterwards, unify the origin of the chitinous hooks and rods that are found in various parts of the body.

The connective-tissue and chitinous penis of *Monocotyle* seem to me to afford a starting point for another type of copulatory organs, that of the penis of *Dictidophora* and *Calicotyle*. In the latter genus (Pl. XIX, fig. 11) the bulbous penis, or as it may be called the *bulbus copulatorius*<sup>1)</sup>, is a kidney-shaped mass of fibrous connective tissue around the terminal portion of the vas deferens, before it is continued into the tubular chitinous penis. The latter is essentially similar to that of *Monocotyle*, and is enclosed in the genital atrium which has here been reduced to a mere sheath for the chitinous penis. The *bulbus copulatorius* may be regarded as a further differentiation in a different direction of such penis as that of *Monocotyle*, in consequence of which it has been almost completely separated from the surrounding tissue. The only difference is that in *Monocotyle* it projects into the genital atrium, while in *Calicotyle* it does not, and is therefore traversed by the vas deferens. The connective-tissue penis of *Dictidophora* (Pl. XI, fig. 4) is essentially similar in structure—histological details and the shape not considered—to that of *Calicotyle*. The chitinous penis is, however, replaced by the hooks already described. These are also, in my opinion, formed by the local transformation of the lining membrane of the genital atrium, and are therefore homologous in a broad sense to the chitinous penis of *Calicotyle* and *Monocotyle*. Unlike, however, what occurs in these genera the lining membrane has in *Dictidophora* not been raised and prolonged into a tubular form and the whole then changed into a chitinous substance, but it has been raised at some particular points into the particular

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1). Braun—Würmer, p. 475.

shape of the hooks already described, and the raised part chitinated.<sup>1)</sup> It should, however, be observed that the process of absorption has probably played as much part in the formation of the hooks as that of chitination.

The penis in *Octocotyle* is essentially similar to that in *Diclidophora*, but its hooks are more like the atrial spines of *Microcotyle*. In *Onchocotyle* the penis is nothing else than a mass of elastic connective tissue around the terminal portion of the vas deferens, which is separated from the surrounding mesenchyma by a membrane, and is therefore essentially similar to that of *Diclidophora*. The hooks are, however, totally absent.

The atrial spines of *Microcotyle* are, as already described, formed by local, conical elevations and chitinous transformation of the lining membrane of the genital atrium, and are therefore homologous in a broad sense with the chitinous penis and penis hooks of other genera as well as with the hooks which are present in many genera in the posterior sucker or in the posterior part of the body, and with the local chitinous areas of the lining membrane of the suckers (Pl. VI, fig. 4; Pl. XII, fig. 4). I also believe that the chitinous frame-work of the suckers of many genera is homologous with the structures just mentioned, *i. e.*, that it is a product of the local transformation of the investing membrane of the body.

The homologue of the penis of *Monocotyle* and *Hexacotyle* and therefore of *Tristimum* can also be traced in *Microcotyle*. It has already been stated that in some species of this genus, as *M. fusiformis* (Pl. V, fig. 1), *M. caudata* (fig. 3), and *M. sebastis* (Pl. VI, fig. 1), the vas deferens opens at the top of a conical papilla projecting into the genital atrium. This papilla is, in my opinion, the homologue of the penis.

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1). Here I have for convenience used a false expression. In point of fact the process of raising and that of chitination probably proceeded simultaneously.

A penis similar to that of *Tristomum* occurs according to Poirier,<sup>1)</sup> among the Digenea, in *Distomum clavatum*, *D. verrucosum*, *D. insigne* and *D. Megnini*. In these forms, however, it has a much simpler structure than in *Tristomum*; and it should moreover be remarked that in the two last-mentioned species it is also traversed by the uterus and that in *D. verrucosum* it does not prominently project into the genital atrium, and somewhat approaches in form that of *Onchocotyle* in having its tissue distinctly separated from the surrounding mesenchyma.

It will be observed that in my descriptions I have nowhere used a term corresponding to "Cirrusbeutel (poche de cirrhe, tasca del pene)" so often met with in the literature on the Trematodes and the Cestodes. This I have done with an express purpose. The term "Cirrusbeutel" and those that correspond to it have been used to designate various structures by different writers. Leuckart<sup>2)</sup> uses it for "ein keulen- oder birnförmiges Organ von ansehnlicher Grösse und wesentlich muskulöser Beschaffenheit, ... der das Endstück des Samenleiters, den sog. Ductus excretorius, in sich einschliesst." Poirier<sup>3)</sup> on the other hand uses it in *D. insigne* and *D. Megnini*, in which a distinct penis is present, for an ovoid sac around the terminal portion of the vas deferens, which has a distinct wall and contains the prostate glands together with a comparatively small quantity of connective tissue; while Monticelli<sup>4)</sup> seems to use it for the penis itself, reserving the word penis for that terminal portion of the vas deferens (*i. e.* the *ductus ejaculatorius*) which is evaginated during copulation. In view of these various significations of the term, and considering that the so-called "Cirrusbeutel" is not a hollow organ, but simply a mass of specially

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1). Poirier—*l. c.*

2). Leuckart—Parasiten. II. Aufl., 1 Bd. p. 43.

3). Poirier—*l. c.* pp. 551 & 553; Pl. XXXIII, fig. 1 & Pl. XXXIV, fig. 1.

4). Monticelli—Studii, p. 80 *et infra*.

modified tissue around the terminal part of the vas deferens, which has been set off from the surrounding mesenchyma by a membrane or a layer of muscular fibres, I have thought it advisable to abandon its use altogether and to adopt the terminology used in this paper. The term "cirrus" has been used by many writers for the spines either of the penis or of the genital atrium.

3. *The prostate gland* (= Körnerdrüse of Lang and Graff, Penisdrüse of Ijima) has been described in other members of the Plathelminthes, and I believe I have succeeded in demonstrating it in the monogenetic Trematodes generally.

4. *Homology of the canalis genito-intestinalis*—I shall now proceed to discuss the homology of this problematic canal and endeavour to throw some light on the question; and in doing this I shall be led to consider also the homology of the vagina and the uterus of the Cestodes as well as the vagina of the ectoparasitic Trematodes and the Laurer's canal of the Digenea. Before, however, expounding my own opinion, it will not be out of place here to bring together the views of preceding writers.

The genito-intestinal canal of the Monogenea was discovered in its right connection by Ijima<sup>1)</sup> (*Polystomum*, *Axine*, *Octobothrium*). To the question, which of the two canals, the vagina or the genito-intestinal canal, is the homologue of the Laurer's canal<sup>2)</sup> his answer is not decisive either way. He says, "Was nun den Zusammenhang der Scheide mit dem Oviduct anbelangt, so findet er entweder direkt (*Calicotyle*, *Pseudocotyle*, *Axine*) oder indirekt durch den Dottergang statt. In ersterer Hinsicht finde ich keine wesentliche Abweichung von den meisten von uns bekannt gewordenen Fällen des Laurer'schen Kanals. In zweiter Hinsicht erinnere ich an das Öffnen

1). Ijima—Ueber den Zusammenhang d. Eileiters mit d. Verdauungskanal bei gewissen Polystomeen. Zool. Anz., Jahrg. VII, 1884, p. 635.

2). The use of this name I shall confine to the Digenea.

des Laurer'schen Canals in den Dottergang bei *Distomum hepaticum*."

Leuckart<sup>1)</sup> regards the genito-intestinal canal as homologous with the Laurer's canal and applies this name to the former. He says, "Die Scheide von *Polystomum integerrimum* erscheint hiernach als ein Gebilde, welches, da es neben dem Laurer'schen Kanale existirt, demselben nicht homolog sein kann." He is of the opinion that the supposed (by Lorenz) opening of the genito-intestinal canal into the vitellarium can no more be regarded as an objection against his view than that the unpaired condition of the vagina in certain monogenetic Trematodes can be advanced as an objection against its homology with the paired vagina of *Polystomum*. "Jedenfalls," he warns us in conclusion, "ist das, was man bei den Trematoden als Scheide bezeichnet, nicht ohne Weiteres überall als dasselbe Gebilde in Anspruch zu nehmen und als Laurer'scher Kanal zu bezeichnen." Leuckart is inclined to regard the Laurer's canal as being homologous with the vagina of the Cestodes.

Wright and Macallum<sup>2)</sup> after describing the canal in *Sphyrnura*, say, "How such an economical method of disposing of surplus yolk can have been arrived at, whether by the modification of a Laurer's canal or otherwise, we are unable to say."

Monticelli<sup>3)</sup>: "Lasciando indiscussa la questione, se serve o no il canale di Laurer come organo di accoppiamento, ..... giudicando ora la cosa dal punto di vista puramente morfologico, io credo, come del resto parmi pienamente giustificabile, che il canale di Laurer dei digenetici per la sua posizione e il suo decorso, per i suoi rapporti con l'ovidotto interno e con gli organi femminile in generale e per la presenza di uno slargamento vesicolare, paragonabile al ricettacolo

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1). Leuckart—Parasiten, II. Aufl., 1. Bd., 1886, p. 58-59.

2). Wright and Macallum—Sphyrnura Osleri. Journ. of Morphology, Vol. I, 1887, p. 42.

3). Monticelli—Saggio, 1888, pp. 53-59.

seminale interno dei monogenetici, rappresenti morfologicamente parlando la vagina dei digenetici, come già Blumberg aveva pensato .....In favore di queste interpretazione, va ancora considerato che nei digenetici non vi è altra parte dell' apparecchio genitale che possa riguardarsi come una vagina." I am afraid the language used by the writer is somewhat confusing ; but his view is unmistakable, as may be seen from another passage, in which after speaking of the genito-intestinal canal, he says, "Ad ogni modo si è tuttora in presenza di fatti che vogliono essere ancora meglio investigati, ma non parmi che questi abbiano, nello stato attuale delle nostre conoscenze, valore tale da impedire di stabilire una omologia del canale di Laurer dei digenetici con la vagina dei monogenetici, d'altra parte la presenza del canale cosiddetto escrezione nei Polystomidae..., come nei Microcotylidae potrebbe benissimo riguardarsi come un adattamento speciale in queste subfamiglie."

In his recently published work,<sup>1)</sup> which I received while I was writing this paper, he has further expounded the same view. In it he speaks of the Laurer's canal throughout as vagina, and regards it as homologous with the vagina of the monogenetic Trematodes. He says, "Ho conservato il nome di *vagina*, e non quello di *canale di Laurer*, perchè le mie nuove ricerche ed i miei nuovi studii comparativi mi confermano nelle conclusioni alle quali io ero pervenuto nel mio saggio, che essa, morfologicamente rappresenta, nei Distomi ed in tutti gli endoparassiti, la vagina dei monogenetici ; cosicchè i due organi devono riguardarsi omologhi : e ciò, sia per i rapporti che esso canale degli endoparassiti contrae con l'ovidotto che ripetono le istesse condizioni che si verificano in quelli (infatti, come nei monogenetici la vagina può apprirsi, o nell'ovidotto, o nel ricettacolo semi-

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1). Monticelli—Primo contributo etc. (Studii sui Trematodi endopar.). Zoolog. Jahrbücher, III. Suppl., 1893. p. 93 *et infra*.

nale, o, insieme a questo, nell'ovidotto, oppure nel ricettacolo vitellino), sia per la sua posizione e per il suo decorso." And further on he adds, "*Mi importa qui assai di far notare che nessuna omologia esiste fra il canale vitello-intestinale..... e la vagina degli endoparassiti: esso è tutt'altra formazione e niente impedisce che possa coesistere con la vagina, e considerarsi ed essere un adattamento speciale in alcuni monogenetici.*"

Pintner<sup>1)</sup> is of the same opinion as Monticelli. He holds the Laurer's canal as homologous with the vagina of the Cestodes. But it seems to me that he infers the homology of these canals from their analogy, and I fear he has not on the other hand taken the genito-intestinal canal sufficiently into consideration.

Braun<sup>2)</sup> also regards the Laurer's canal as the homologue of the vagina of the Monogenea. After observing that in those cases where the vaginal opening is situated ventrally or on the lateral margin of the body, it lies asymmetrically with regard to the median line of the body, he says, "Demnach dürften wir die doppelten Vaginen als ursprünglich ansehen, aus denen durch Atrophie der einen, und zwar der rechten, das Verhalten von *Onchocotyle* etc. hervorgegangen ist; diese unpaare Vagina rückt dann seitlich mit ihrer äusseren Mündung und schon bei *Axine* sieht dieselbe dorsal, wie Lorenz berichtet, so das von da bis zu dem Verhalten von *Octobothrium* nur ein relativ kleiner Schritt ist; an letztere Gattung würden sich in diesem Punkte die Digenaea anschliessen; trotz der verschiedenen Verbindungsstellen halte ich demnach diese Kanäle für homologe Bildungen." It should be remarked that the writer regards the genito-intestinal canal of *Onchocotyle* as the vagina—an error which is quite natural, as the true

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1). Pintner—Neue Beiträge zur Kenntniss des Bandwurmkörpers. Wiener Arbeiten, T. 9, 1890.

2). Braun—"Würmer" in Bronn's "Klassen und Ordnungen des Thierreichs," 1890. pp. 489—490.

vagina of this genus has been made known for the first time by these studies.

Hatschek<sup>1)</sup> in his "Lehrbuch" has the following passage: "Bei *Polystomum* findet sich nebst dem primären weiblichen Ausführungsgang..... und dem Laurer'schen Gange noch ein paariger, rechts und links mündender weiblicher Begattungsgang; auch bei *Calicotyle* und anderen ist letzterer beobachtet." It is unmistakable that in this passage the writer designates the genito-intestinal canal as the Laurer's canal.

Brandes<sup>2)</sup> in criticising the view of Pintner, says, "Dass der Laurer'sche Kanal morphologisch der Vagina der Cestoden und ectoparasitischen Trematoden entspricht, ihr also homolog ist, hat bisher meines Wissens noch Niemand bezweifelt....."; and further on he adds, "Der Laurer'sche Kanal der entoparasitischen Trematoden ist der Vagina der ectopar. Trematoden und der Cestoden homolog, aber nicht analog, die Vagina der letzteren ist der Uterusmündung der ersteren analog, aber nicht homolog." I am afraid the writer is going too far when he infers from the silence of most authors on the homology of the vagina of the Cestodes that they have no doubt of its homology with the Laurer's canal of the Digenea. In his work on the Holostomidae published the previous year, the same writer seems to have expressed a somewhat different view; for, after stating the ground of his disbelief in the supposed function of the Laurer's canal as a passage for the surplus product of the vitellarium, he says,<sup>3)</sup> "Auf jeden Fall, meine ich, darf man annehmen, dass bei dem Bedürfnisse eines Abflussrohres für überschüssiges Material sich die

1). Hatschek—Lehrbuch der Zoologie, 3. Lieferung, 1891, p. 343-344.

2). Brandes—Zur Frage des Begattungsaktes bei den entopar. Trematoden. Centralbl. f. Bakter. u. Parasitk., Bd. 9, 1891, p. 265 *et infra*.

3). The italic is mine.



Vagina der Cestoden in *besserer* Weise den neuen Verhältnissen angepasst haben würde."

Dieckhoff,<sup>1)</sup> who directed his attention specially to the *canalis genito-intestinalis*, is of the same opinion as Braun, under whose direction his studies were made. After describing the canal in different species studied by him he says, "Ijima glaubte eine Nebeneinanderstellung desselben mit dem Laurer'schen Kanal der Digenea nicht von der Hand weisen zu dürfen. Da aber auch bei Thieren mit unpararier, dorsal mündender Vagina, wie z. B. bei *Octobothrium lanceolatum* und *Diplozoon paradoxum*, ein in den Darm führender Kanal existirt, und da auch überhaupt die Ableitung des Laurer'schen Kanales aus den paarigen Vaginen, wie mir scheint, genügend dargethan ist, so ist dieser Gedanke wohl nicht annehmbar"; and a little further on he adds, "Vorläufig muss man in dem Canalis vitello-intestinalis eine Bildung *sui generis* sehen, deren genetische Beziehungen ganz fraglich sind."

Quite recently Looss<sup>2)</sup> has advanced a view which presents considerable differences from those of the preceding writers. He considers the question from a purely morphological point of view and comes to the conclusion that the uterus of the Trematodes is homologous with the vagina of the Cestodes, the uterus of the latter with the Laurer's canal of the Digenea and with the *canalis genito-intestinalis* of the Monogenea. The vagina of the latter he regards as a structure *sui generis*.

I have already in a preliminary paper<sup>3)</sup> discussed briefly the

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1). Dieckhoff—*l. c.*

2). Looss—Ist der Laurer'sche Kanal der Trematoden eine Vagina? Centrbl. f. Bakter. u. Parasitk., Bd. 13, 1893. p. 808 *et infra*.

3). Der Laurer'sche Kanal und die Scheide. Centrbl. f. Bakter. u. Parasitenkunde, Bd. 14, 1893. p. 797.

differences of my view from that of the last mentioned writer, and I shall now proceed to explain it more at length.

Let us in the first place consider the vagina of the Monogenea. So far as I know this organ is truly paired only in *Onchocotyle*, *Calicotyle*, *Polystomum*, and *Sphyranura*. In the first two genera its external opening is situated on the ventral side of the body, while in the other two genera it is situated on the lateral margins. In *Calicotyle* it opens into the oviduct, but in all the other three genera it becomes continuous with the yolk-duct. In *Microcotyle*, *Axine*, and *Hexacotyle* the vaginal opening is situated on the dorsal side in the median line of the body (or sometimes on the lateral margin as in *Axine belones* according to Lorenz); but that the vagina in these forms has been derived from a truly paired one seems to me beyond doubt. Thus, in *Axine heterocerca* the vagina immediately divides right and left into two canals, which proceeds backwards, keeping symmetry with respect to the median line of the body; in *Microcotyle reticulata*, *M. chiri*, *M. truncata*, and in *Hexacotyle* the vagina remains a single duct for a certain distance in the median line of the body, but then divides into two canals; in *M. fusiformis*, *M. caudata*, and some other species of the same genus the vagina remains single for a longer distance; in *Microcotyle sciacnae* the paired vaginal canals unite with and separate from each other twice during their course; while finally in *Axine aberrans* the vagina remains single throughout its whole extent, and opens into the fore end of the unpaired yolk-duct. Lorenz<sup>1)</sup> in one place figures the vagina in *Axine belones* as opening directly into the oviduct, but in another figure (fig. 2) he represents it as opening into the yolk-duct. Considering his figures alone I should trust the former figure as showing more details; but

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1). l. c.—Taf. I. fig. 4.

unfortunately it is not in accordance with my observations on a closely allied species (*Axine aberrans*), in which the vagina opens, as stated above, into the yolk-duct. If now we eliminate the case of *Axine belones* as requiring further examination, we have in the above mentioned forms a perfect series of vaginae from a truly paired to as truly an unpaired condition—*Onchocotyle* and *Calicotyle* standing at one end of the series and *Axine aberrans* standing at the other. In *Monocotyle*, *Tristomum*, and *Epibdelia* the external opening of the vagina is single and is situated on one side of the body. In *Monocotyle* it opens into the oviduct from the ventral side; while in *Tristomum* and *Epibdelia* it opens into the yolk-reservoir more to the left or right. The latter fact has been regarded by Braun as indicating the formation of the vagina in these species by the simple atrophy of one of the originally paired vaginae; but the relation of things above mentioned in *Monocotyle*, considered together with the evidently close systematic relationship of this genus with *Calicotyle*, seems to me to point strongly to the view that its unpaired vagina has been formed by the union and subsequent displacement towards one side, of the originally paired vaginae, and not as Braun supposes by the atrophy of one of them. That the vagina in *Octobothrium lanceolatum*—a form the single vagina of which Braun regards as due to the atrophy of one of the originally paired vaginae—has been formed by the union of the originally paired vaginae seems to me evident from its exact similarity to *Axine aberrans* both in the position of its external opening as well as in its relation with the yolk-ducts as described by Dieckhoff; and in *Tristomum* and *Epibdelia* the displacement of the external opening of the vagina towards one side of the body may have entailed a similar displacement of its internal opening. I therefore go one step farther and regard the unpaired vagina—whether its opening be situated on the ventral or on the dorsal side, or whether it be in the

median line of the body or otherwise—as formed by the union of the originally paired vaginae, such as we now meet with in *Calicotyle* and *Onchocotyle*. As a further support to this view it may be mentioned that in *Dactylogyrus* and *Tetraonchus* the unpaired vagina, which is present only on one side of the body, opens according to my own observation, into the oviduct in the median line of the body at the same level as the paired yolk-ducts, just as in *Monocotyle*. This view appears to me to be more in accordance with the actual state of things than the other, in favour of which hardly a single positive fact can, as it seems to me, be brought forward.

Let us now turn our attention to that problematic organ, the *canalis genito-intestinalis*. This canal is less widely distributed among the ectoparasitic Trematodes than the vagina: of the genera I have hitherto studied it is present only in *Diplozoon*, *Microcotyle*, *Axine*, *Otocotyle*, *Dictidophora*, *Onchocotyle*, and *Hexacotyle*. According to my own observations it seems to be wholly wanting also in the *Gyrodactylidae*.<sup>1)</sup> It always opens at one end into the oviduct near where the latter receives the unpaired yolk-duct—in fact the genito-intestinal canal and the yolk-duct sometimes open opposite, or side by side with, each other; but usually the two openings are more or less separated from each other; and in this case that of the genito-intestinal canal is situated in some species nearer and in others farther from the ovary than that of the yolk-duct. The wall of the genito-intestinal canal presents nothing special except that in some species it presents circular thickenings at stated intervals.

As a preliminary step to the discussion of the homology of the

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1). I beg to remark here that in my paper on *Diplozoon* (p. 185) I alluded to the vagina of *Dactylogyrus* as being similar to the genito-intestinal canal. I then suspected that these canals might be homologous with each other; but on further reflection such a view seems to me untenable.

*canalis genito-intestinalis* we must consider that of the vagina of the Cestodes.

Until quite recently the vagina of the Cestodes appears to have been generally regarded as homologous with the Laurer's canal of the distomes; but a careful examination of this view convinces me that hardly a single positive proof can be cited in its favour, and that it is grounded on a mistaken estimate of the analogy (as opposed to homology) that has been supposed to exist between the two organs. Looss<sup>1)</sup> has however recently shown that the vagina of the Cestodes is to be regarded as the homologue of the uterus of the Trematodes. On my part I entirely agree with him on this point, and will briefly recapitulate the reasons that led me to this conclusion, even before I had read Looss' paper.

If we cast a glance on the genital organs of the Plathelminthes (the Nemertinei excepted), we find that in all the three classes two ducts open to the exterior, *i. e.*, to the morphologically external surface of the body, near each other. One of them is the vas deferens; the other is in Turbellaria the efferent duct of the ovary, while in the Cestodes and Trematodes it is called respectively the vagina and the uterus; but in these classes it is likewise the direct continuation of the oviduct. In *Caryophyllæus tuba*, indeed, the uterus opens, according to Monticelli<sup>2)</sup>, side by side with the vagina, and in *C. mutabilis*, according to Will<sup>3)</sup>, it unites with the vagina, so that in this genus the uterus and not the vagina corresponds in the position of its external opening to the uterus of the Trematodes. But the uterine opening seems to be very unstable in its position in the Cestodes; for in *Amphilina* it is near the anterior end of the body,

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1). Looss.—*l. c.*

2). Monticelli—*Appunti sui Cestodaria*. p. 5.

3). Heinrich Will—*Anatomie von Caryophyllæus mutabilis*. Zeitschr. f. wiss. Zool. Bd. 56, 1893. Taf. II. fig. 17

while in the *Bothriocephalide* it is on the ventral or the dorsal side according to the species. In contrast therewith the vaginal opening of the Cestodes is very constant in its position and is situated close to that of the vas deferens. The vagina of the Cestodes and the uterus of the Trematodes I therefore regard as homologous structures, having as they do their external openings always near that of the vas deferens, and both being the direct continuation of the oviduct.

Which now of the two ducts, the vagina or the genito-intestinal canal, of the ectoparasitic Trematodes is the homologue of the Laurer's canal of the Digenea?

In the first place, the position of the genito-intestinal canal corresponds very well with that of the Laurer's canal—and be it remarked that I confine the latter term to the Digenea: both arise from the oviduct between its origin and the ootyp, near or opposite the opening of the yolk-duct. The striking difference is that one opens to the exterior while the other communicates with the intestine; but this is in my opinion of quite a secondary importance, and can not be regarded as a serious reason against the homology of the two canals, any more than the absence of any external opening of the uterus in *Tenia* can be regarded as against its being homologous with the uterus of *Bothriocephalus*. In the second place the Laurer's canal is admitted by most writers<sup>1)</sup> to present an abortive character, and in many species of the Digenea it is totally wanting; and the same seems to me to hold true of the genito-intestinal canal of the Monogenea. Thus it has no definite function; for the explanation of Ijima seems to me, as it has seemed to others, to be rather forced, and as Prof. Ijima himself now admits it to be in conversation; then,

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1). Looss, Monticelli, Brandes, etc.

its wall presents in some species circular thickenings just as in some distomes; and in many genera it is totally absent. Considering these correspondences of the two canals I believe them to be homologous structures—the Laurer's canal and the genito-intestinal canal. As already mentioned in the historical portion, some writers maintain that the Laurer's canal is homologous with the vagina of the Monogenea; but several considerations speak against this view. Thus, the vagina of the monogenetic Trematodes opens in the majority of species into the yolk-duct, and where it opens directly into the oviduct it does so side by side with the yolk-ducts; while the Laurer's canal mostly takes its origin directly from the oviduct. In *Distomum hepaticum*, indeed, the Laurer's canal was supposed to open into the yolk-duct, but Leuckart<sup>1)</sup> and Poirier<sup>2)</sup> have distinctly proved that it opens not into the yolk-duct but into the oviduct, side by side with the unpaired yolk-duct. So far as I know, there only remains in this respect the case of *Dist. cylindraceum*, in which, according to Monticelli,<sup>3)</sup> the Laurer's canal opens into the yolk-reservoir. Now the difference in this respect between the two canals under consideration will be found by any one who will take the trouble to examine the actual state of things in each particular case to be very much more considerable than can be expressed by a single general statement (*cf. e.g.* the various figures); and the single case above mentioned (which it is, however, very desirable to examine more closely) can not be regarded as a serious objection against my view. Then, the Laurer's canal may, according to Monticelli<sup>4)</sup>, be regarded as “una continuazione e dipendenza dell'ovidotto,” since its wall has the same structure as that of the latter. This, however, can not be maintained with any

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1). Leuckart—Die menschl. Parasiten. II. Aufl. pp. 53, 321, 238.

2). Poirier—*l. c.* Pl. XXX., fig. 4.

3). Monticelli—Primo contributo etc. p. 106.

4). *l. c.* p. 106.

degree of plausibility for the vagina of the Monogenea, as will be apparent from the descriptions already given and a comparison of my figures; while, on the other hand, it holds very well for the genito-intestinal canal, the wall of which is, as already mentioned, characterised in some species by having circular thickenings exactly similar to those of the oviduct; and Dieckhoff<sup>1)</sup> has even expressed the view that the canal may perhaps be a rudimentary (abortive?) oviduct. Add to these the considerations that the vaginæ of the Monogenea are clearly seen to have been originally paired, while on the other hand we have no trace of the paired condition of the Laurer's canal and of the genito-intestinal canal; that the latter was regarded as, and called by some writers, the Laurer's canal so long as they believed it to open to the exterior (Taschenberg in *Onchocotyle*) or to be in direct continuation with the vas deferens of the other individual (Zeller in *Diplozoon*); and finally that the genito-intestinal canal, like the Laurer's, "può apprirsi, o nell'ovidotto, o nel ricettacolo seminale (as in *Hexacotyle*) o, insieme a questo, nell'ovidotto," the evidences in favour of my view—that the genito-intestinal and the Laurer's canal are homologous with each other—seem to me to be very strong, much stronger than the evidences that can be brought forward in favour of the other view, which appears far from being "irrefutable."

I have said above that we have no evidence of the fact that the genito-intestinal canal was originally paired. There are, however, some statements that require consideration in this respect. According to Zeller<sup>2)</sup> the genito-intestinal canal is, in *Polystomum integerrimum*, situated indifferently on the left or on the right side of the body,

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1). Dieckhoff—*l. c.* p. 243.

2). Zeller—Weiterer Beitrag zur Kenntniss der Polystomen. Zeitschr. f. wiss. Zool., Bd. 27, 1876. p. 245.



always, however, opposite the side at which the ovary is situated. In *Polystomum ocellatum*, again, the canal is described and figured by Dieckhoff<sup>1)</sup> as lying on the left side; and in *Splyranura Osleri* it is figured by Wright and Macallum<sup>2)</sup> as lying likewise on the left side. On the contrary, in all the species I have examined, the canal is situated, as already mentioned, on the right side of the body; and this led me to ask Prof. Ijima whether he had not observed such a position of the canal. He very kindly examined the serial sections of two individuals of *Polystomum ocellatum* which he had at hand, and he has informed me that the canal is situated on the right side in both. This perhaps shows the necessity of a reëxamination of the statements to the contrary effect; but as this is at present impossible for me to do, I shall only remark that they do not oblige us to regard the genito-intestinal canal as having been originally paired, any more than the varied position of the common genital pore in *Tenia* compels us to infer its having been paired originally.

It will be remembered that one of the reasons that have led Monticelli to assert the homology of the Laurer's canal with the vagina of the Monogenea is that "nei digenetici non vi è altra parte dell'apparechio genitale che possa riguardarsi come una vagina." But if instead of starting with the assumption that a morphological equivalent of the vagina of the Monogenea must exist in the Digenea, he had put the question simply as we have done, he would have been led not to make the positive statement we have quoted, denying all homology of the genito-intestinal canal with the Laurer's.

In my paper on *Diplozoon*<sup>3)</sup> I expressed the opinion that the recep-

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1). Dieckhoff—*l. c.* p. 250.

2). *l. c.*

3). Goto—*l. c.* p. 184.

*taculum vitelli* described by Voeltzkow<sup>1)</sup> in *Aspidogaster conchicola* is homologous with the genito-intestinal canal, and this seems to me to be more probable now that I have shown the homology of the genito-intestinal canal with the Laurer's. For, according to Voeltzkow the *receptaculum vitelli* arises in *Aspidogaster* as a solid string of cells, which reaches the ectoderm on the dorsal side and there spreads out in the form of a funnel. It is therefore exceedingly probable that the canal originally opened to the exterior on the dorsal surface of the body, just as the Laurer's canal now does in the distomes. Hence I regard it as homologous with the Laurer's and therefore with the genito-intestinal canal.

It still remains to inquire whether the Cestodes have any organ homologous with the Laurer's canal or with the vagina of the Monogenea. My answer is that they all possess a homologue of the latter, and some (*Amphilina*) also one of the former.

Let us begin our comparison with the unsegmented forms of the tapeworm, which have recently been erected by Monticelli<sup>2)</sup>, under the name of *Cestodaria*, into a separate class of the same grade as that of the Trematodes or the Cestodes. Thanks to the investigations of that zoologist the anatomical relations of the genital organs of these forms have been clearly exposed. In *Amphilina* there are two vaginae, one posterior and opening outwards near the posterior end of the body near the external opening of the vas deferens, the other anterior and ending blindly after proceeding for a certain distance forwards from the beginning of the oviduct. Now, everybody will allow that the posterior vagina of this worm corresponds mor-

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1). Voeltzkow—*Aspidogaster conchicola*. Würzburger Arbeiten. Bd. 8, 1888. p. 263 & 279.

2). Monticelli—*Appunti sui Cestodaria*. Estratto dal vol. V, ser. 2, No. 6, degli Atti della R. Accademia delle Scienze fis. e mat. di Napoli, 1892.

phologically to the vagina of other tapeworms and is homologous with it. What then is the blind vagina? My answer is that it is the homologue of the genito-intestinal canal of the Monogenea and therefore of the Laurer's canal. What has struck me as a remarkable coincidence is that all these organs bear a decidedly abortive character. That the Laurer's and the genito-intestinal canal appear to be in the process of gradual disappearance has been already explained, and will, I think, be admitted by most persons; and the blind vagina of *Amphilina* appears to me as unmistakably abortive—the very fact of its being blind and its total absence in the nearly related form *Caryophyllaeus* speaking strongly for this view. Then, it bears at its beginning a *receptaculum seminis* just like Laurer's canal in most of the distomes or the genito-intestinal canal in some Monogenea (*Hexacotyle*). Again, if, as I have explained above, the *receptaculum vitelli* of *Aspidogaster* is homologous with the Laurer's canal, we have another similarity between it and the accessory vagina of *Amphilina*, in their both ending blindly. Lastly, the relation of this vagina to the oviduct is exactly the same as that of the Laurer's or of the genito-intestinal canal to the oviduct in the Trematodes. I therefore believe them all homologous with one another. The blind ending of the canal in *Amphilina* may have been brought about by a simple abortion of its terminal portion, as in *Aspidogaster*, or by a total disappearance of the alimentary canal, with which it had been connected as it now is in many species of Monogenea.

I am now going to propound the opinion which may seem to many exceedingly heterodox, that the uterus of the Cestodes is homologous with the vagina of the monogenetic Trematodes. But to make my arguments properly appreciated it is necessary to explain my conception of the relations of the various genital ducts in the Cestodes. In these the uterus has, I believe, usually been regarded as

the direct continuation of the oviduct, and the vagina as an accessory duct. From a physiological point of view this conception is quite correct—the ovum in fact passes from the ovary into the uterus. But, as I have already explained above, this mode of conception seems to me morphologically not correct. I regard the vagina as the direct continuation of the oviduct, and both the yolk-duct and the uterus as accessory ducts opening into the former. And in accordance with this view I regard that portion of the genital duct in *Tenia* and *Caryophyllæus*<sup>1)</sup> (Pl. XXVII, figs. 5 & 6) which lies between the beginning of the vagina and the beginning of the uterus as the *yolk-duct*. It may be objected that the position of the shell-glands, which are in other forms always situated around a portion of the oviduct, is against such a view. But the shell-glands being evidently a special physiological provision, I believe that their position must not be regarded as constant; in fact, they do vary considerably in position even among the monogenetic Trematodes; and if they can be displaced in one direction there seems to me to be no reason why they can not be displaced in another, provided only that there be a physiological necessity for it or an advantage gained thereby. I therefore believe that in *Tenia* the shell-glands have shifted position from the initial portion of the vagina (or its homologue, as in the Trematodes) towards the uterus, in consequence of the changed functions of these two canals (*i.e.*, their respective homologues) in the Trematodes and the Cestodes—assuming for the time being that the monogenetic Trematodes present a more primitive state of things. This granted, let us compare the uterus of the Cestodes with the vagina of the monogenetic Trematodes.

The most striking difference between these two structures is that one of them is clearly seen to have been originally paired, while the

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1). Cf. Monticelli's "Appunti [etc.]" and Will's "*Caryophyllæus mutabilis*" (Pl. II, fig. 17).

other presents no trace of such a condition. This difference, however, appears to me to be not so fundamental as to effectually bar the homology of the two ducts, since both the Cestodes and the monogenetic Trematodes must have undergone numerous modifications in different directions since they have diverged from a common stock. This difference, then, being eliminated as of secondary importance, and the blind ending of the uterus in *Tenia* being assumed to be also a secondary modification scarcely requiring further exposition here, there is a remarkable coincidence between the vagina of the Monogenea on the one hand and the uterus of the Cestodes on the other, in their relation with the other genital ducts. Thus, both unite with the yolk-duct at one end and open outwards at the other. It is indeed true that in *Bothriocephalus latus* the uterine pore is situated on the ventral side; but the homologous pore is also on the same side in many species of ectoparasitic Trematodes, as *Tristomum*, *Monocotyle*, etc.; and in many species of *Bothriocephalus* the opening is on the dorsal side, as may be seen from the figures published by Matz<sup>1)</sup> in his paper on *Bothriocephalus*. After all, the position of the external openings is, as Looss has justly remarked, of quite secondary importance, and as already mentioned varies considerably in different members of the same group. In *Bothriocephalus* the uterus can not exactly be said to open into the yolk-duct; on the contrary, the uterus, the oviduct, and the yolk-duct meet at one point; but a similar case occurs in *Monocotyle* among the monogenetic Trematodes. I therefore believe that the uterus of the Cestodes is homologous with the vagina of the Trematodes.

The view above explained seems to me to possess at least one advantage over others, which is that it leaves no residual pheno-

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1). Matz—Beiträge zur Kenntniss der Bothriocephalen. Archiv f. Naturgeschichte, Jahrg. 58, 1. Bd.

menon. For, according to the view of Monticelli and Pintner, the genito-intestinal canal is "un adattamento speciale" in the Monogenea, while according to that of Looss the vaginae of the same are "Bildungen sui generis"—*i. e.*, in logical language residual phenomena. And as to the genito-intestinal canal being a special adaptation in certain members of the Monogenea, it is exceedingly difficult to see how and from what necessity such a canal could have been specially developed in a limited number of forms, while totally wanting in others. Whereas, if we regard the canal as in process of abortion, we meet with no difficulty, and the various facts appear to me capable of being brought into harmony with each other. According to my view, then, the Trematodes and the Cestodes are to be derived phylogenetically from a form which—adopting the terminology applicable at present only to the Monogenea—possessed the paired vaginae, the uterus, and another duct, the homologue of the *canalis genito-intestinalis*. In saying this, however, it should be observed that I by no means assert these organs to have had in the supposed ancestral form the same function as they have now in either of its descendants.

As an addendum to the above discussion I beg to make just one short remark on the vagina of *Diplozoon*. In my paper on *Dipl. Nipponicum*, I have described the vas deferens of one individual as standing in direct connection with the yolk-duct of the other. In doing so I stated merely what I could directly observe; for in my sections I could not distinguish the vagina from the vas deferens. It is true that the terminal portion of what I then considered the vas deferens was exceedingly small, but this portion was not set off by any demarcation from the proximal portion. I fully admit, however, the justness of Pintner's<sup>1)</sup> criticism on this point. I have

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1). Pintner—Nochmals über den Begattungsakt der parasitischen Plathelminthen. Centralbl. f. Bakter. u. Parasitenk., Bd. 9, 1891, No. 22.

indeed virtually admitted the presence of the vagina in *Diplozoon* in my comparison<sup>1)</sup> of it with *Microcotyle*, a genus which seems to me to be closely allied in many respects to the former ; but I did not then sufficiently so consider the theoretical aspect of the question as to clearly express myself on the point.

5. *The Protrusion of the Penis*.—Although I have not had much opportunity to observe it, there can scarcely be any doubt that the true penis as well as the chitinous armature of the genital atrium (of *Microcotyle*) can be protruded. In those forms which have the tubular chitinous penis this is probably the sole part which is protruded and introduced into the vagina of the other individual. On the other hand, in *Tristomum* and *Epibdella*, or more generally in those forms which have a well-developed conical or club-shaped connective-tissue penis it is this which is protruded ; but in this case it is not certain whether it is actually introduced into the vagina of the other individual. It has been a mistake on the part of some writers to draw conclusions as to the inability of the penis to protrude from the smallness of the opening of the genital atrium or the shortness of the penis, and, again, as to its incapability of being introduced into the vagina on account of its great size. It should be remembered that the body in the Trematodes is exceedingly soft and capable of both extension and contraction, as may be seen from Pintner's observation on the copulation of the tapeworm, and mine on the protrusion of the penis in *Tristomum ovale*. As already mentioned, in *Tristomum* some of the diagonal fibres of the body are specially developed around the penis, and no doubt assist in its protrusion ; but in most of the species studied by me there are no protractors ; and in these cases the general musculature of the body is, I think, entirely responsible for the protru-

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1). *l. c.*, p. 187.

sion. If all the sets of muscular fibres of the body contract at the same time, the investing membrane must be subjected to pressure from within, great enough to evaginate the genital atrium and protrude the penis.

6. *Remarks on the Terminology of the Genital Organs*—In consequence of the complicated relation of the genital organs of the Trematodes the same word has, on the one hand, been often used in different senses by different writers, and on the other hand, corresponding organs have been designated by different names. It may therefore not be quite out of place here to compare, without aiming at exhaustiveness, the terms which have been used<sup>1)</sup>; confining our attention mainly to the ectoparasitic Trematodes. In his "Saggio" Monticelli used the term "ovidotto interno" for that portion of the female efferent duct which lies between the ovary and the ootyp; the latter he called "utero"; while the remaining portion, *i. e.*, the portion lying between the ootyp and the external opening, he called "ovidotto esterno." In his recently published "Primo contributo," however, he uses these terms in other senses. Leaving the "ovidotto interno" with the same sense, he now applies the term "utero" to that portion which lies beyond the shell-glands and which "conserva lo stesso calibro," and "ovidotto esterno" for "sua porzione terminale, dove si allarga ad imbuto molto allungata." The term "ootypo" he uses in the sense given it in the present paper.

Wright and Macallum in their paper on *Sphyraxnura* apply the term "uterus" to the ootyp, and use the latter term for that

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1). The descriptions of Vogt in his paper, "Ueber die Fortpflanzungsorgane einiger ectoparasitischer mariner Trematoden" (Zeitsch. f. wiss. Zool., Bd. 30, Suppl., 1878, p. 306-340) are unfortunately so incomplete and obscure that I could not make much use of them. His terminology will not therefore be considered here, lest I should misinterpret his observations.



enlarged portion of the female duct which is found in *Sphyranura* at the junction of the oviduct with the unpaired yolk-duct and the genito-intestinal canal. Those portions of the "oviduct" which lie between the ovary and their "ootyp" and between this and their "uterus" they call respectively the "ovarian" and the "uterine" portion. The portion corresponding to what has been called the uterus in this paper is wanting in *Sphyranura*.

Taschenberg<sup>1)</sup> uses the term "Uterus" for the ootyp and holds any special name for that portion of the female duct which lies beyond it "für völlig überflüssig."

Braun<sup>2)</sup> in his "Würmer" uses the term "ootyp" in the sense it has in this paper. "Keimleiter" or "Germiduct" he calls that portion of the female duct which extends from the ovary "bis derselbe (the duct) mit den Dottergängen in Verbindung tritt." And at page 490 he says, "Was jenseits des Ootyps bis zur weiblichen Geschlechtsöffnung liegt, bezeichne ich als Uterus"; so that according to his terminology strictly taken, no name is left for that portion of the female duct which lies between the opening of the yolk-duct and the ootyp. Perhaps he means to call this portion "Keimdottergang," a term used, as he himself tells us, by Stieda.

It is perhaps hardly necessary to remind the reader that in this paper the term "oviduct" is used for that portion of the female efferent duct which lies between the ovary and the "ootyp"; the latter for that portion which is distinguished by the presence of shell-glands around it; "uterus" for that portion which lies beyond the ootyp. In my paper on *Diplozoon* I called "uterus" all that portion which lies between the genital opening and the ootyp inclusive, and distinguished the latter as "uterus proper." But I find the term "ootyp"

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1). Taschenberg—Weitere Beiträge. p. 37 *et infra*.

2). Braun—*l. c.*, p. 483 & 490.

now so often used by German and other continental writers, and also by some English-writing authors, that I believe myself justified in adopting it too—and in the sense in which it has been used by P. J. v. Beneden<sup>1)</sup> and just now defined in this paragraph.

In conclusion I wish to make a short remark on the terms “vagina” and “Laurer’s canal” as applied to the Monogenea. The former possesses, etymologically speaking, only a physiological signification, and it is very unfortunate that Monticelli has attached to it a morphological meaning, and has called the Laurer’s canal vagina, although, according to his own opinion, not this canal but the “ovidotto esterno” functions as such; so that if we should adopt consistently Monticelli’s terminology we should be led to some such awkward expressions as “the vagina of the endoparasitic Trematodes is not a true vagina but the ‘ovidotto esterno.’” “Laurer’s canal” now so familiar to helminthologists ought, in my opinion, to be retained, as its homology is still under discussion. It is, on the other hand, not advisable to apply the name to the vagina of the Monogenea, as has been done by some writers. For, in the first place, we have for this group such a good name as “vagina,” and in the second place—and this is a very serious objection—the homology of the two canals is far from being yet made out. It is therefore to be hoped in the cause of science that we shall use non-committal terms, and simply speak of the “vagina” of the Monogenea, and the “Laurer’s canal” of the Digenea.

## B. Biological Notes.

HABITAT—The particular habitat of each species will be stated in the systematic part of this paper; but some general facts must be noted down here. By far the greater number of ectoparasitic Tre-

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1). P. J. v. Beneden—*l. c.* p. 15.

matodes live attached to the gill of the fish ; but many live in the mouth-cavity or on the general surface of the body. For instance, *Tristomum Nozawae*, the specimens of which I owe to my friend Mr. S. Nozawa of the Fisheries Bureau of the Hokkaidō Chō, was found, according to my friend's statement, attached to the fins of *Thynnus sibi*. *Monocotyle Ijima*e I have found parasitic in the mouth-cavity of *Trygon pastinaca*, and *Declidophora sessilis* and *Declid. elongata* respectively in that of *Chacrops Japonicus* and *Pagrus tumifrons*. It is stated by Monticelli<sup>1)</sup> that some species of *Octocotylidae* are parasitic on *Cymothoa* ; I have once found a single specimen of *Declidophora elongata* attached to the caudal segment of a *Cymothoa*, and according to Prof. Ijima's statement in manuscript *Declidophora smar*is was also found attached to a *Cymothoa*. But as Prof. Ijima remarks, these facts alone cannot be taken as proving that these Trematodes are true parasites of the *Cymothoa* ; for all the other specimens of *Declidophora elongata* which I have collected from the same host were found attached directly to the wall of the mouth-cavity, and therefore the single specimen that was attached to the *Cymothoa* must be regarded as accidental. It is, however, quite otherwise with *Tristomum biparasiticum*. In the first place, every one of the specimens of this species that I have collected was attached to the carapace of a copepod, probably of the genus *Parapetulus*, parasitic on the gill of *Thynnus albacora* ; and in the second place, a very curious relation exists between the Trematode and the copepod. I have namely found the egg of the former attached to the ventral side of an abdominal segment of the copepod. In most specimens two eggs were attached to one individual in like positions on the two sides, but in some I have found only one. The egg I have reproduced in fig. 4a, Pl. XXV ; and as may be seen from the figure, the chitinous shell

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1). Monticelli—Saggio, p. 18.

consists of numerous concentric layers and is provided at one end with a hollow filament, by means of which the egg is attached to the host. In view of these facts, it can scarcely be doubted that we have here a case which can not well be brought under the category of either commensalism or parasitism; for the Trematode seems to derive its food, like other species, from the gill of the fish, deriving only some advantage by attaching itself and its eggs to the body of the copepod. It is not, however, clear to me what advantage the parasite derives by attaching its eggs to the copepod.

Another interesting fact may be here mentioned. It is this, that *Tristomum sinuatum* and *Tristomum orale*, which inhabit the same host (*Histiophorus* sp.), keep strictly separate from each other, and appear never to wander one into the habitat of the other. *T. orale*, namely, is found in the mouth-cavity—on its wall or on the branchial arches—while *T. sinuatum* is confined to the inner surface of the branchial plates—the branchial filaments of the same series coalescing in the above mentioned fish with each other and forming a single plate. I have never found any specimen of *T. orale* attached to the gill; nor have I any of *T. sinuatum* on the outer surface of the gill plate. Perhaps this depends on the nature of food of the two species, *T. sinuatum* living on blood, while *T. orale* seems to live on the slime of the mouth-cavity; but then it is not easy to see why *T. sinuatum* never wanders out to the outer surface of the gill-plate.

LOCOMOTION—The locomotory movements of some ectoparasitic Trematodes have been described by Haswell<sup>1)</sup> and Monticelli<sup>2)</sup>; and I have observed similar movements in *Tristomum sinuatum*, *Monocotyle Ijimai*, and some species of *Microcotyle*. When on one

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1). Haswell—On Temnocephala, an Aberrant Monogenetic Trematode. Quart. Journ. of Mic. Sc., vol. XXVIII, 1888. p. 282 *et infra*.

2). Monticelli—Saggio. pp. 19-20.

occasion I kept a few specimens of *M. caudata* just taken from a very fresh fish, on a glass slide covered with sea-water, these executed what Haswell calls "looping" movements (*spannende Bewegung*) like those of the leech. The worm, namely, first attached its anterior end to the slide, apparently by means of the anterior suckers, and dragging after it the hinder part of its body, attached the caudal disc close up to the anterior end by means of the posterior suckers, the body in the meanwhile being folded on itself on the ventral side so as to form a loop; the worm then let go the anterior end and stretching its body, again attached it to the slide, detaching at the same time the posterior suckers, which were then again brought close up to the anterior end, and so on. The looping movement is slow in *Microcotyle*, but in *Monocotyle* it is very rapid and energetic and is just like that of an excited leech. The worms moved quite rapidly while on the host, but when I transferred them to a watch-glass filled with sea-water, they at once began wandering about so quickly that each looping movement could only just be distinguished, and now and then they groped about with the anterior extremity of their body, thus showing apparently signs of surprise. The posterior sucker of this worm, containing as it does the striped muscular fibres already described, adheres very strongly to external objects—not only to the surface of the mouth-cavity but also to a smooth surface such as that of the watch-glass. *Tristomum sinuatum* executes locomotion quite rapidly but still much more slowly than *Monocotyle*. The comparatively small posterior sucker of this worm is capable of adhering very tightly to the surface of the gill. When the worm advances its anterior suckers to attach them to the substratum, it stretches out its body to such an extent that it becomes much elongated and its breadth is reduced to about one-third its length. Besides the looping movement which all the three species above mentioned are able to execute, I have also

observed in *Monocotyle* and *Tristomum* those twisting movements mentioned by Haswell and Monticelli. These worms, namely, are capable of moving their bodies in lateral directions while keeping the posterior sucker attached to a fixed substratum. This is due to the crossing of the muscular fibres that enter the sucker from the body and form the irregular radial fibres of the sucker already described—those coming from the right side of the body going to the left side of the sucker and those from the left going to the right. In this connection it may be mentioned that in many specimens of *T. sinuatum* which were killed with hot sublimate or heat alone, the posterior suckers were seen to have been more or less rotated from their normal position—a fact due to the unequal contractions of the irregular radial fibres of the suckers.

In all the three species above mentioned the anterior suckers are chiefly used for attaching the anterior end of the body in locomotion. In *Monocotyle* indeed there is, properly speaking, no anterior sucker; but the special development of the dorso-ventral fibres already described serves in its stead. In *Microcotyle* the anterior end is seen, when it is being attached to a hard substratum such as a glass slide, to become much broadened out. This seems to be brought about by a partial evagination of the mouth-cavity, by which the suckers are brought in direct contact with the external object. In *Tristomum*, on the other hand, the mouth, *i.e.*, in this case the anterior end of the pharynx, was often seen to be not in close contact with the substratum, while the suckers were closely applied to it.

FOOD—The majority of the species described in this paper live on the slime of the host; but some are also able to extract its blood. For instance, I have observed many specimens of *Tristomum sinuatum* whose alimentary canal was gorged with blood, and they in conse-

quence looked much redder than they really were—this species possessing a light flesh-red colour of its own.

COLOURATION—Most of the monogenetic Trematodes that I have studied may be described as having a colourless and transparent body; but since the internal organs are more or less visible from the exterior the body appears coloured. The only real exceptions in this respect that I have observed are *Tristomum sinuatum* and *T. rotundum*, which possess, as just mentioned, a light flesh-red colour of their own; but in which tissue of the worm this colour is lodged I have not been able to make out; possibly it may be in the investing membrane. The specimens of *Hexacotyle acuta* that I have myself collected had all a dusky colour like that of the gill of its host, but those that were collected by my friend Mr. Nozawa were perfectly colourless except where the vitellarium was seen through, which is in this species more or less dusky coloured. I therefore believe that the generally dusky colour of my specimens was due to a greater development of the vitellarium.

The only internal organs that possess any colour of their own are the vitellarium and the pigment cells of the intestine already described. In fresh specimens the former looks dark and granular by incident light, and slightly yellowish by transmitted light; while the pigment cells of the intestine look dark brown or perfectly black by both incident and transmitted light. The body of most ectoparasitic Trematodes being thus transparent and allowing the substratum to be seen through—for the vitellarium is in fresh specimens not conspicuously dark, and the intestinal pigment-cells are not close enough to each other to constitute a single visible object—they are somewhat difficult to detect at first sight. This, however, must not be regarded as a case of protective colouration; for in the first place, the nature of the habitat already protects the parasites from being at-

tacked by their enemies, and in the second place, they are but very imperfectly exposed to light, and thus the conditions of their existence prevents any effective play of natural selection.

INJURY TO THE HOST—On this head I am only able to add an observation or two to that of v. Baer on *Nitzschia elongata* mentioned by Braun.<sup>1)</sup> It has already been said that *Tristomon sinuatum*, like *Diplozoon Nipponicum*, can extract blood from the gill of the host, and thus may cause some injury to it. In one case I observed that a specimen of *Dididophora elongata* had caused an abnormal excrescence to form around its caudal disc, which, together with the posterior part of the body proper, was thus completely immersed in the excrescence and hidden from view.

### C. Systematic.

In this part of my paper I shall confine myself to the characterisation and description of the genera and species studied by myself, leaving their systematic classification to those who may have occasion to study personally a larger number of forms and especially to reëxamine the species previously described. Owing to incompleteness in the literature I could gain access to, I have not been able to make the historical notices as exhaustive as I could wish ; they are, however, published with the hope of lightening, in ever so slight a degree, the labours of future workers in this field. For the reason above stated I have also been compelled to satisfy myself in many places with second hand quotations and references. In such cases the authorities are invariably mentioned.

Before proceeding to the systematic descriptions of the different genera and species, I wish to remark once for all with special em-

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1). Braun—Würmer. p. 512.



plasis, on the usefulness for systematic purposes of the examination of the hooks which are often present near the posterior end of the body. Drawings of them made from glycerine-gelatine preparations as mentioned at the beginning of the present paper would be of invaluable service in the identification of species. Indeed, different species of the same genus can be distinguished and identified with a good degree of certainty by proper examination of these hooks alone. When one has a new species before him and yet has not time enough to make a sufficiently minute study of it, he would do well to add to its more prominent characteristics a sketch of the hooks from a glycerine-gelatine preparation, care being taken to bring them to such a position as to enable him to get a good view of the characteristic form—a job which can usually be effected with ease by repeatedly melting the imbedding medium and giving proper shifts and pressure to the cover-glass.

## I. MICROCOTYLE, P. J. v. Beneden et Hesse.

This genus was first erected in 1863 by P. J. van Beneden and Hesse with the following diagnosis<sup>1)</sup>: “Une partie du corps est séparée en arrière par un étranglement et porte, des deux côtés du corps, un très-grand nombre de petites ventouses à crochets. Les œufs sont munis d’un filament aux deux pôles.” These writers have described five species, *viz.*, *M. labracis* from the gill of *Labrax lupus*, *M. canthari* from the gill of *Cantharus griseus*, *M. donacani* from the gill of *Labrus donacani*, *M. erythrinii* from the gill of *Pagellus erythrinus*, and *M. chrysophrisii* from the gill of *Chrysophris vulgaris*.

In 1878 Vogt<sup>2)</sup> described a new species, *M. mugilis*, from the gill of *Mugil cephalus*. According to this writer this genus should be united with *Aciine*, since “die innere Organisation ist durchaus dieselbe, nur ist bei *Aciine orphii* ... der Vordertheil des Körpers weit mehr in die Länge gezogen und schmal, während zugleich das

1). P. J. v. Beneden et Hesse—Recherches sur les Bdellodes et les Trématodes marins. p. 112.

2). Vogt—Ueber die Fortpflanzungsorgane einiger ectopar. marin. Trematoden. Zeitschr. f. wiss. Zoolog., Bd. 30, Suppl., 1878.

Hinterende mit den Saugnapfen noch etwas schief zur Achse des Körpers steht als bei den typischen Microcotylen." In the same year Lorenz<sup>1)</sup> described another species, *M. mormyri*, from the gill of *Pagellus mormyrus*, and shed much light on its anatomy and histology.

Parona and Perugia<sup>2)</sup> have recently (1889 & 1890) described four additional species, viz., *M. sargi* from the gill of *Sargus Rondeletii*, *S. annularis*, and *S. vulgaris*, *M. alcedinis* from the gill of *Smaris alcedo* and *Mania vulgaris*, *M. trachini* from the gill of *Trachinus radiatus*, and *M. salpae* from the gill of *Boe salpa*. These writers have also minutely redescribed all the pre-existing species and added a valuable contribution to our knowledge of the general anatomy of the genus. Finally in 1891 Sinsino<sup>3)</sup> described a new species from the gill of *Umbrina cirrhosa*, and named it *M. Pancerii*.

It has already been mentioned above that according to Vogt this genus should not be separated from *Axine*. Lorenz, on the other hand, decidedly maintains its separation as a distinct genus. The distinctive characteristics are according to him (1) that *Microcotyle* is perfectly symmetrical in external form, the symmetry showing itself especially in the form of the caudal disc, (2) that in *Microcotyle* the penis is absent and that the vas deferens and uterus open outwards by distinct apertures, while in *Axine* both have a common opening, (3) that in *Microcotyle* the vagina is situated on the dorsal median line, while in *Axine* it is situated on the lateral margin, and (4) that in *Microcotyle* a large number of eggs are found in the uterms at the same time, while in *Axine* only one egg is found at a time. Parona and Perugia, who studied nearly all the species hitherto known, say, "Differenze salienti fra *Axine* e *Microcotyle* stanno nell'avere il primo vagina laterale ed armata ed il secondo mediana; e nel portare un'unica serie di ventose caudali l'*Axine* e due il *Microcotyle*."

According to my own observations every one of the distinctions mentioned by the preceding writers falls away. (1) As already stated, *M. reticulata* and *M. sciencu* have a decidedly asymmetrical form, while in some other species a slighter degree of

1). Lorenz—Ueber die Organis. d. Gattung. Axine u. Microcotyle. Wiener Arbeiten., Bd. 1, Hft. 3, 1878.

2). Parona e Perugia—Res ligusticae, XIV. Contribuzione per una monografia del genere Microcotyle. Estratto dagli Annali del Museo Civico di Storia Naturale di Genova, ser. 2, vol. X, 1890.

3). Sinsino—Di un nuovo Microcotyle raccolto dall' Umbrina cirrhosa. Proc. verb. d. Soc. Tosc. di Scienze Natur., 1891. Cited on the authority of St.-Remy.

asymmetry presents itself in some internal organs, as in the different lengths of the two branches of the intestine. (2) In all the species of *Microcotyle* what Lorenz calls "Penis" is distinctly present<sup>1)</sup> as also the genital cloaca, and his observation as to the separate opening of the male and female ducts is, as Parona and Perugia have pointed out, erroneous. (3) In the species of *Aeine* which I have studied, and which are described below, the vagina is situated, as in *Microcotyle*, on the dorsal median line. (4) I have observed some specimens of *Aeine heterocerca* discharge, while kept in sea-water in a watch-glass, a large number of eggs from the uterus, which was afterwards found to be much enlarged in consequence. (5) In all the three species of *Aeine* I have studied, two series of suckers are distinctly present, although one of the series is much reduced in number. Thus we find no absolute difference between the two genera, the difference lying only in the degree in which the asymmetry is manifested in each. Still the general form of the two genera presents quite a perceptible difference, so that we may keep them distinct for convenience' sake. A sharp distinction between two such nearly allied genera can not be expected.

In view of the facts above summarised, the diagnoses given by the preceding writers are no longer quite satisfactory; I therefore venture to modify them as follows:

Body elongated, mostly symmetrical, with the anterior end rounded and the posterior end usually pointed. With a pair of suckers in the mouth-cavity. The caudal disc, which is in most species separated from the body proper by lateral constrictions, usually bears a large number of minute suckers. Genital cloaca present; genital opening on the ventral median line; vaginal opening single, situated in the median line on the dorsal side. No chitinous hooks at the posterior end of the body.

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1). Cf. Parona and Perugia—Res ligusticae, XIV. p. 8.

*I. Microcotyle caudata*, n. sp.

(Pl. I, fig. 1; Pl. II, fig. 7; Pl. III, figs. 7, 8, 9, 10;

Pl. IV, figs. 7 & 8; Pl. V, fig. 3; Pl. VI, fig. 3.)

*Body*<sup>1)</sup> elongated, about 3.2 mm. in length, symmetrical. *Anterior sucker* with a membranous septum. Common *genital opening* on the same level as the beginning of the intestinal trunks; *atrial spines* conical and slightly curved, the longest measuring 0.01 mm. *Ovary* situated at about the middle of the whole length of the body, with the oviduct end on the right side, thence extending towards the left, presenting a convex border in front. On being folded on itself on reaching the left intestinal trunk, it turns again towards the right, and on reaching its oviduct end takes a backward direction and ends at the anterior end of the testes by being folded once on itself. The single, median *vagina* is situated about six times as far forwards from the anterior end of the ovary as it is behind the genital opening; it leads into a single, median canal, which, after proceeding backwards half way towards the anterior end of the ovary, divides right and left into two canals. These, the paired *vaginal canals*, after proceeding backwards for a short distance, become continuous with the paired yolk-duets. The *genito-intestinal canal* takes its rise from the oviduct exactly opposite the unpaired yolk-duct, and after proceeding for a short distance backwards and towards the left side of the body, suddenly turns towards the right, and finally opens into the intestinal trunk of the right side. The *vitellaria* of the two sides are very distinct in front; but posteriorly the boundary between the two can not usually be distinguished. The *paired yolk-duets* begin at about the end of the anterior third of the whole length of

1). In this as in the following species, the curvatures of the body, when there are any, are not taken into account. I would point out also that the length of the body varies considerably according to the different state of contraction, and that therefore much weight should not be laid on it in the identification of species.

the body, and unite in the median line at the level of the hinder end of the anterior third of the ovary. The *testes* occupy a little less than one quarter of the whole length of the body and are situated behind the ovary; they are large and are about 23 in number. The two main trunks of the *intestine* send out lateral branches both inwards and outwards; the left trunk is longer than its fellow, and extends beyond the vitellarium into the caudal disc, while the right trunk ends with the vitellarium. The *caudal disc* is about  $\frac{1}{4}$  the length of the whole body, and is narrow. *Posterior suckers* about 25 on each side; breadth 0.045–0.08 mm.

*Habitat*—Gill of *Sebastes* sp. sp. (Jap. Mebaru and Kin-mebaru).

*Locality*—Mitsugahama (Prov. Iyo).

*Date*—August 1889.

## 2. *Microcotyle sebastis*, n. sp.

(Pl. I, figs. 2 & 3; Pl. III, fig. 1; Pl. IV, figs. 1, 4, & 5.)

*Body* about 5.5 mm. long, slender, symmetrical. *Anterior sucker* with a septum. Common *genital opening* a little in front of the point of bifurcation of the alimentary canal; *atrial spines* conical, slightly curved, the longest about 0.017 mm. *Ovary* long, situated at about the middle of the entire length of the body; the anterior portion is  $\wedge$ -shaped and the posterior portion somewhat S-shaped with its left anterior end continuous with, and folded on, the leg of the  $\wedge$ ; the hindmost terminal portion being folded many times on itself. *Vaginal opening* single, median, and dorsal, situated about thrice as far in front of the anterior end of the ovary as it is behind the common genital opening. The *vaginal canal* continues single for about half way towards the anterior end of the ovary, then divides, and the two ducts thus formed, after traversing about one-third their way towards the ovary, become continuous with the *paired yolk-ducts*.

These unite with each other at the level of the front end of the posterior S-shaped portion of the ovary, and the *single yolk-duct* opens into the oviduct at a little distance from the beginning of the ootyp. The *genito-intestinal canal* opens into the oviduct about midway between the origin of the latter and the beginning of the ootyp. The *vitellaria* of the two sides are entirely distinct both in front and behind; they end anteriorly near the point of bifurcation of the alimentary canal, and posteriorly with the body proper, not extending into the caudal disc, but leaving the posterior portion of the intestinal trunks naked. *Testes* occupying a little less than one-fifth the whole length of the body, posterior to the ovary; of rather small size, about 40 in number. The two trunks of the *intestine* sending out only a few short branches towards the median side; the left leg longer than the right, and both extending for a certain distance into the *caudal disc*. This occupies about  $\frac{1}{3}$  the whole length of the body. *Posterior suckers* about 29 on each side; breadth 0.068-0.128 mm.

*Habitat*—Gill of *Sebastes* sp. (Jap. Ma-zoi and Nagara-zoi).

*Locality*—Hakodaté.

*Date*—August 1890.

### 3. *Microcotyle elegans*, n. sp.

(Pl. I, fig. 4; Pl. V, fig. 2.)

*Body* about 4 mm. long, slender, symmetrical. *Anterior sucker* with a septum. Common *genital opening* a little in front of the beginning of the intestinal trunks; *atrial spines* conical, about 0.005 mm. in length; a few spines being also present on the posterior wall. *Ovary* in the anterior half of the body, its hinder end being nearly at the middle of the whole length. Its anterior half is intermediate in form between the corresponding portions of *M. caudata* and *M. sebastis*; the posterior half is S-shaped, and the terminal portion is

folded many times on itself. *Vaginal opening* single, median, and dorsal, situated four times as far in front of the anterior end of the ovary as it is behind the common genital pore. The *vaginal canal* continues single for a little more than half its whole course towards the ovary, then divides, and the two canals after traversing one-fourth their way towards the ovary become continuous with the *paired yolk-ducts*. These unite at the level of the anterior end of the S-shaped portion of the ovary, and the *single yolk-duct* thus formed opens into the oviduct about midway between the beginning of the ootyp and the point where the former receives the *genito-intestinal canal*. This opens into the oviduct about half-way between the origin of the oviduct and the beginning of the ootyp. The *vitellaria* of the two sides are entirely distinct both in front and behind; ending anteriorly at some distance from the point of bifurcation of the alimentary canal, and reaching posteriorly the terminations of the intestinal trunks, of which the left extends beyond the right. *Testes* occupying a little less than one quarter of the whole length of the body; of large size, about 27 in number. The trunks of the *intestine* sending out numerous short branches on the inner side; the left trunk longer than its fellow; both extending into the caudal disc, and entirely surrounded by the vitellarium. *Caudal disc* a little longer than  $\frac{1}{3}$  the entire length of the body; *posterior suckers* about 50 on each side; breadth 0.040–0.068 mm.

*Habitat*—Gill of *Seombrops chilodipteroides* (Jap. Mutsu).

*Locality*—Misaki.

*Date*—December 1889.

#### 4. *Microcotyle reticulata*, n. sp.

(Pl. I, fig. 5; Pl. III, figs. 2, 3, & 4; Pl. IV, figs. 2 & 3; Pl. V, figs. 5 & 6.)

*Body* 6–10 mm., or more, long, elongated, and slightly asymme-

trical. *Anterior sucker* without any septum. With only a single pair of *sticky glands* near the anterior end of the body. Common *genital opening* just behind the posterior end of the oesophagus; *atrial spines* straight and conical, about 0.016 mm. in length, composed of two parts, the basal, hemispherical portion and the distal, spinous portion mounted on the former. *Ovary* slender, situated at about the middle of the whole length of the body; roughly speaking, S-shaped, and making numerous minor windings, especially in its anterior half. *Vaginal opening* single, median, and dorsal, armed with low conical teeth, and situated at a short distance behind the common genital opening. The single *vaginal canal* divides into two at a point which is as far behind the external opening of the vagina as this is behind the genital opening; and the two *vaginal canals* after proceeding backwards for a short distance, become continuous with the paired *yolk-ducts* at the point marked with an \* in fig. 5, Pl. I. The *paired yolk-ducts* unite at about the anterior end of the ootyp, and the single *yolk-duct* opens into the oviduct just where this is continued into the ootyp. The *genito-intestinal canal* opens into the oviduct about twice as far from the origin of the latter as from the beginning of the ootyp. The *vitellaria* of the two sides are distinct in front; the lobes are small and scattered, and are situated mainly on the dorsal side of the intestine. *Testes* occupying a little less than one-half the whole median portion of that part of the body which lies behind the posterior end of the ovary; of small size and very numerous. The terminal portion of the *vas deferens* (Pl. V, fig. 6) is armed with conical spines just like those of the genital atrium. The branches of the *intestine* form a complicated net-work (Pl. III, fig. 2). *Caudal disc* continuous with the rest of the body. *Posterior suckers* occupying somewhat more than one-third the entire length of the body; more numerous and smaller in size on the right than on the left side, there being about



42 on the right and only 23 on the left side; breadth 0.075-0.227 mm.

*Habitat*—Gill of *Stromateus argenteus* (Jap. Mana-gatsuwo).

*Locality*—Mitsugahama.

*Date*—August 1889.

5. *Microcotyle truncata*, n. sp.

(Pl. II, figs. 1 & 2; Pl. III, fig. 6; Pl. V, fig. 7.)

*Body* about 3.3 mm. long, slender, pointed anteriorly, and ending posteriorly with a truncate, triangular caudal disc. Common *genital opening* on the same level with the point of bifurcation of the alimentary canal; *genital atrium* armed with twenty rods about 0.13 mm. in length,<sup>1)</sup> arranged in a circle which is incomplete on the dorsal side. The S-shaped *ovary* is situated in the front half of the body, the hinder end lying at the middle of the whole length of the body. Its anterior third is large, but its posterior two-thirds are slender, and it presents a slight enlargement at the posterior end which is in close contact with the foremost testes. The single, median, dorsal *vaginal opening* is situated a little more anteriorly than midway between the common genital opening and the front end of the ovary. *Vaginal canal* goblet-shaped, the mouth of the goblet corresponding to the external vaginal opening, and the bottom communicating with the *paired yolk-ducts*. These, proceeding backwards, unite with each other at about the level of the front end of the ootyp, and open into the oviduct midway between the origin of the oviduct and the beginning of the ootyp. The *genito-intestinal canal* opens into the oviduct just opposite the yolk-duct. The *vitellaria* of the two sides are quite distinct both in front and behind, reaching in the former region up to the very point of bifurcation of the alimentary canal. Here also the

1). The apparent difference of length in fig. 2, Pl. II, is, as stated in the anatomical part, probably due to the fact that the ventral ones are looked at not quite perpendicularly to their long axes.

lobes of the two sides are closely applied to each other so as to appear almost continuous. *Testes* occupying two-fifths of the entire length of the body, posterior to the ovary; of moderate size and numerous. The *vas deferens* presents a sudden expansion at the level of the beginning of the paired yolk-ducts and remains large up to its opening into the genital atrium. The trunks of the *intestine* send but a few short branches towards the median line; and both end behind on the same level. *Caudal disc* very short. *Posterior suckers* 10 on each side; breadth 0.055–0.072 mm.

*Habitat*—Gill of *Pristipoma Japonicum* (Jap. Isaki).

*Locality*—Mitsugahama.

*Date*—August 1889.

6. *Microcotyle fusiformis*, n. sp.

(Pl. II, fig. 3; Pl. IV, fig. 6; Pl. V, fig. 1.)

*Body* about 2 mm. long, symmetrical, fusiform in outline. *Anterior sucker* with a septum. Common *genital opening* a little anterior to midway between the hinder end of the pharynx and that of the oesophagus; *atrial spines* small, conical, about 0.007 mm. in length. The *ovary* when viewed from the ventral side has nearly the shape of an interrogation-point; the front half large, and the hinder half slender. *Vaginal opening* single, median, and dorsal, situated behind the common genital opening two-fifths the whole distance between this and the front end of the ovary. The *vaginal canal* continues single until within the last fifth of the above distance, then bifurcates; and the two canals thus formed immediately become continuous with the *paired yolk-ducts*. These unite at a short distance in front of the level of the origin of the oviduct, and open into it just opposite the genito-intestinal canal at a short distance from the beginning of the ootyp. The *vitellaria* of the two sides are distinct

in front, but apparently continuous behind. *Testes* occupying a comparatively small area about one-sixth the whole length of the body, posterior to the ovary; of moderate size and comparatively few in number (about 15). No lateral branches on the median side of the *intestinal trunks*; the left trunk longer than the right. *Caudal disc* continuous with the rest of the body, and the *suckers* occupying nearly one-half the whole lateral borders of the body; suckers 30-33 or more on each side; breadth 0.046-0.065 mm.

*Habitat*—Gill of *Centronotus rubulosus* (Jap. Gimpō).

*Locality*—Mitsugahama.

*Date*—August 1889.

7. *Microcotyle chiri*, n. sp.

(Pl. II, figs. 4 & 5; Pl. III, fig. 5; Pl. V, fig. 4.)

*Body* about 4.2 mm. long, symmetrical, slender in the anterior portion where the vitellarium is absent, but the remaining portion much broader, rounded at both ends. Common *genital opening* situated a little in front of the hinder end of the oesophagus; *genital atrium* with a hemispherical, cup-shaped organ on the dorsal side, the inner surface of which is covered with spines similar in shape to those of *M. reticulata*, and about 0.015 mm. long. The front half of the *ovary* follows in its course nearly the three sides of an isosceles triangle whose apex is directed backwards; and the posterior half is many times folded on itself into a close, irregular spiral. *Vaginal opening* single, median, and dorsal, nearly half as far behind the common genital opening as it is before the front end of the ovary. The *vaginal canal* divides into two at a point which is about half as far from the vaginal opening as from the anterior end of the ovary, and the two canals, after traversing only a short distance, become continuous with the *paired yolk-ducts*. These unite a little in front of the

anterior end of the ootyp, and the *single yolk-duct* thus formed opens into the oviduct about midway between the beginning of the ootyp and the opening of the *genito-intestinal canal*. The latter opens into the oviduct at the beginning of the last third of the whole course of the oviduct. The *vitellaria* of the two sides are quite distinct in front as well as behind, though the lobes of the opposite sides come close to each other. *Testes* occupying a narrow region between the two trunks of the intestine, posterior to the ovary; rather small in size; about 25 in number. No lateral branches on the median side of the *intestine*; the two intestinal trunks of equal length, and nearly reaching the posterior end of the body. *Caudal disc* continuous with the rest of the body; *suckers* occupying the posterior half of the lateral border of the body; about 30 on each side; breadth 0.090–0.140 mm.

*Habitat*—Gill of *Chirus hexagrammus* (Jap. Ainamé).

*Locality*—Hakodaté.

*Date*—August 1890.

8. *Microcotyle sciaenae*, n. sp.

(Pl. II, figs. 6 & 6 a; Pl. VI, fig. 2.)

*Body* about 4 mm. long, slender, asymmetrical, rounded at the anterior end and pointed posteriorly. *Anterior sucker* with a septum. Common *genital opening* on the same level as the beginning of the intestinal trunks; *genital atrium* armed with two sets of chitinous rods arranged in circles (Pl. VI, fig. 2, *a* & *b*). The longer ones (*a*) are about 0.11 mm. long, each presenting two curvatures in opposite directions, and are situated just in front of the opening of the vas deferens. Only a small, terminal portion of these rods projects into the cavity of the atrium, the remaining portion lying imbedded in the mesenchyma. The other shorter ones (*b*) have the form of a hook and are about 0.02 mm. in length. These are arrang-

ed at the mouth of the cylindrical sac before spoken of, the curved portion projecting into the cavity of the atrium and the remaining portion lying in the wall of the sac and the surrounding mesenchyma. *Ovary* consisting of a  $\wedge$ -shaped anterior portion and a posterior but slightly slenderer portion which is turned spirally twice in the same direction and once folded on itself in the opposite direction at the hinder end. *Vaginal opening* a little less than twice as distant from the front end of the ovary as it is behind the genital opening. The *vaginal canal* immediately divides into two; and the two canals thus formed proceed a little way backwards, and turning to the ventral side of the vas deferens unite on the dorsal side of the uterus, then again separate from each other and become continuous with the *paired yolk-ducts*. These begin in front of the anterior end of the ovary at the distance of two-fifths the whole distance between the ovary and the common genital opening, and unite with each other at the end of the foremost third of the antero-posterior extension of the ovary. The single duct thus formed opens into the oviduct about midway between the beginning of the ootype and the opening of the *genito-intestinal canal*. The latter opens into the oviduct at the end of the anterior two-thirds of the course of the oviduct. The *vitellaria* of the two sides are entirely distinct both in front and behind, extending into the caudal portion and surrounding the two intestinal trunks. *Testes* occupying about two-fifths the whole length of the body proper, posterior to the ovary; large; about 27 in number. No branches on the median side of the *intestine*, the two trunks of which extend far into the caudal disc and are in this region wholly destitute of lateral branches; the right trunk describing a larger curve in consequence of the general asymmetry of the body. The *caudal disc* is bent at an angle to the body proper and is only a little shorter than it. *Posterior suckers* about 75 on the right and 60 on the left side; breadth 0.048-9.110 mm.

*Habitat*—Gill of *Sciaena sinu* (Jap. Ishimochi or Guchi).

*Locality*—Mogi (near Nagasaki).

*Date*—July 1889.

## II. AXINE, Abildgaard.

This genus was erected by Abildgaard towards the close of the last century. He described in 1794 a species, *A. belones*, from the gill of *Esox belones*. In 1836 Diesing divided it into two species, *Heteracanthus pedatus* and *H. sagittatus*; but in his "Systema helminthum" he again united them into a single species.<sup>1)</sup> In 1861 P. J. v. Beneden<sup>2)</sup> again described the same species and made some observations on the genital opening and the spines with which it is armed. He also observed the similarity of the suckers to those of *Diplozoon*. In 1863 the same writer in conjunction with Hesse<sup>3)</sup> described two species, *A. orphii* from the gill of *Esox belone* and *A. triglae* from the gill of *Trigla hiruudo*. The former, is, however, granted by later writers to be identical with *A. belones*, already described by v. Beneden. Finally in 1878 Lorenz<sup>4)</sup> published a very detailed account of the anatomy and histology of *A. belones*.

In accordance with the facts mentioned in the anatomical part of the present paper I give the generic diagnosis as follows:

Body elongated, anteriorly slender, but broad posteriorly. In consequence of an unequal development of the two sides of the caudal disc the body is asymmetrical, and the posterior end occupies a lateral position. The longer side of the caudal disc bears numerous suckers, is either convex or straight, and is bent at an angle to the lateral border of the body proper; the other side bears only a small number of suckers or (?) none at all. No chitinous hooks at the posterior end of the body. With a single,

1). Diesing—Systema helminthum, vol. I, p. 425.

2). P. J. v. Beneden—Mémoire sur les vers intestinaux, p. 53.

3). P. J. v. Beneden et Hesse—Recherches sur les Bdellodes et les Trématodes marins. p. 116-117.

4). Lorenz—Untersuch. ü. d. Organisation d. Gattung. Axine u. Microcotyle. Wiener Arbeiten, Bd. I, Hft. 3, pp. 3-20.

dorsal, median or a lateral vaginal opening. With a pair of egg-shaped or spherical suckers in the mouth-cavity.

*1. Axine heterocerca*, n. sp.

(Pl. VII, figs. 1, 2, 3, 4; Pl. VIII.)

*Body* flat, about 10 mm. long, with a form roughly like that of the blade of a Turkish sword, with a convex border behind. Common *genital opening* situated a little behind the termination of the oesophagus. *Ovary* at the posterior end of the middle third of the body, comparatively small, long, following in its general course the three sides of a triangle, the apex of which is directed towards the front end of the body, and making numerous smaller windings; its exact form is as represented in fig. 1, Pl. VII, and fig. 5, Pl. VIII. *Oviduct* arising from the ovary on the right side of the body, and bearing a small *seminal receptacle* close to its origin, proceeds backwards and towards the left, and is continued into the ootyp in the median line of the body. The *uterus* proceeds from the ootyp straight forwards and opens into the genital atrium. *Vaginal opening* single, dorsal, median, situated as far behind the common genital opening as this is behind the pharynx. The *vaginal canals* are paired from the beginning, and proceeding backwards on the inner side of the intestinal trunk are continued into the paired yolk-duets at the point marked with \* in fig. 1, Pl. VII. With a second dorsal opening behind the vaginal opening, which ends blindly. The *vitellaria* of the two sides are wholly separate in front; but their boundary behind can not be distinguished; extending from the level of the vaginal opening to near the posterior extremity of the body. *Paired yolk-duets* arising from the vitellarium on each side at the level marked with \* in fig. 1, Pl. VII, and proceeding backwards as the direct continuations of the vaginal canals, unite with each other in the median line of the body, on the

ventral side of the uterus. The *single yolk-duct* thus formed then proceeds almost straight backwards and opens into the oviduct where this is continued into the ootyp. *Genito-intestinal canal* arising from the oviduct at the middle of its course, and proceeding forwards and towards the right, opens into the intestine. *Testes* occupying a little less than two-thirds of the whole median portion of the body lying posterior to the ovary, of moderate size, tolerably numerous. *Vas deferens* describing numerous convolutions on its way towards the genital atrium. *Oesophagus* sending out numerous lateral branches. *Intestinal trunks* with numerous branches both on the inner and outer sides; those of the former, however, mostly very short. With about 30 *suckers* on one side and only 9 on the other; the largest of these, lying at about the middle of the longer side, measuring 0.600 mm. in breadth, and the smallest 0.065 mm.

*Habitat*—Gill of *Seriola quinqueradiata* (Jap. Buri or Hamachi).

*Locality*—Hiroshima (Ujina Port), Mitsugahama, and Misaki.

*Date*—August 1889 (H. & Mits.); December 1890 (Mis.).

## 2. *Axine aberrans*, n. sp.

(Pl. VII, figs. 5 & 6.)

*Body* about 5 mm. long, flat, lanceolate, curved on one side, and with a straight, posterior border making acute angles with the lateral borders. Common *genital opening* situated about  $\frac{1}{8}$  the whole length of the body from the anterior end. *Genital atrium* armed with conical spines. *Ovary* situated at the hinder end of the front half of the body, nearly cylindrical, bent on itself in the form of the letter U, and with the open end directed forwards. The *oviduct* arises from the ovary a little on the right side of the median line; and after proceeding for a short distance forwards, suddenly bends backwards, and after proceeding in the same direction, suddenly bends forwards and is continu-



ed into the ootyp. It bears a small, globular *receptaculum seminis* at a short distance from where it bends backwards towards the ootyp. The *uterus* proceeds from the ootyp almost straight forwards toward the genital atrium. *Vaginal opening* single, dorsal, median, situated about as far behind the common genital opening as this is from the anterior end of the body; it leads into a single *vaginal canal*, which proceeds straight backwards on the dorsal side of the vas deferens and opens into the yolk-duct just where the paired yolk-ducts unite with each other. The vaginal canal is armed with conical spines near its external opening. *Vitellarium* of each side distinct only at the anterior end, extending from between the vaginal and the common genital opening to near the posterior border of the body. *Paired yolk-ducts* arising about midway between the common genital opening and the front end of the ovary, and soon uniting with each other in the median line on the ventral side of the uterus. *Unpaired yolk-duct* proceeding almost straight backwards and opening into the oviduct just where this bends backwards towards the ootyp. *Genito-intestinal canal* arising from the oviduct side by side with the unpaired yolk-duct and proceeding forwards and towards the right finally opens into the intestine. *Testes* of moderate size, tolerably numerous, occupying a little less than  $\frac{2}{3}$  the whole median portion of the body. *Genital atrium* as well as the terminal portion of the vas deferens armed with conical spines. *Suckers* of but slightly unequal size, measuring 0.040–0.058 mm. in breadth; about 25 on one side and only one on the other.<sup>1)</sup>

*Habitat*—Gill of *Belone schismatorhynchus* (Jap. Datsu).

*Locality*—Hagi.

*Date*—July 1889.

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1). In reality there may be more. My specimens were, as already stated, collected some time after the death of the worms, and consequently some of the suckers may have been torn away.

3. *Axine triangularis*, n. sp.

(Pl. VII, figs. 7 &amp; 8.)

*Body* about 1.5 mm. long, flat, broad, and triangular, with an almost straight posterior border. Common *genital opening* close behind the termination of the oesophagus. *Ovary* at about the anterior end of the last third of the whole body; form like that of an interrogation-point when looked at from the ventral side. *Oviduct* arising a little on the right side of the median line; and thence proceeding backwards is swollen into a *receptaculum seminis*, which is wound spirally once on itself. Beyond the seminal receptacle the oviduct again proceeds backwards, and after receiving the genito-intestinal canal, bends towards the left, and at the same time proceeding posteriorly, is continued into the ootyp on the median line of the body just in front of the testes. From the ootyp the *uterus* proceeds along the median line towards the genital atrium. *Vitellarium* of each side distinct both in front and behind, extending from the level of the common genital opening to near the posterior extremity of the body. *Paired yolk-ducts* arising a short distance in front of the anterior end of the ovary and soon uniting with each other on the median line. The *unpaired yolk-duct* proceeds backwards along the median line and bending towards the right at the level of the ootyp opens into the oviduct at a short distance from where the latter receives the genito-intestinal canal. *Testes* rather small, only about 12 in number. *Genital atrium* with a circular, cup-shaped organ like that of *Microcotyle chiri*, the diameter of which is about 0.035 mm., and the internal surface of which is covered with conical spines. *Oesophagus* exceedingly short. *Intestinal trunks* sending out numerous bifurcating branches on the outer side, but only shallow evaginations on the inner. *Suckers* about 36 on one side and only 6 on the other; breadth 0.04–0.06 mm.

*Habitat*—Gill of *Anthias Schlegelii* (Jap. Akasagi).

*Locality*—Misaki.

*Date*—December 1889.

### III. OCTOCOTYLE, Diesing.

This and the following genus *Dictidophora* have been combined by most writers under the name of *Octobothrium*. The latter name is due to F. S. Leuckart<sup>1)</sup> whose original diagnosis runs: “Corpus elongato, depresso, plano; apertura oris antica, infera, simplice; in utroque partis corporis posticae latere acetabula suctoria quator.” He, however, included in it at least two groups of forms which are, in my opinion, to be separated from each other and placed in distinct genera. So far as I have been able to make out with a somewhat scanty access to the literature of the subject, especially the older, Diesing is the first writer who has made this distinction and erected two genera, which respectively include those forms which are, in my opinion, to be brought under at least two distinct genera. One of these has been named by him *Octocotyle*, the diagnosis of which he gives as follows<sup>2)</sup>: “Corpus elongatum depressum. Caput corpore continuum. Os terminale. Acetabula in postico corporis margine uncinis duobus subbasilaribus interjectis utrinque quator, prominula orbicularia inermia (?) et duo parallela infra os sita. Apertura genitalis feminea elliptica uncinulorum corona simplici cincta. Penis.....Porus excretorius.....Piscium marinorum ectoparasita.” The other of his genera is *Dictidophora*, the original diagnosis<sup>3)</sup> of which ran: “Corpus subovale v. sublanceolatum depressum. Caput corpore continuum. Os subterminale. Acetabula in margine caudali octo, solitaria, valvulis 4 membranaceis assereculatis, in cardine transverso mobilibus, longe pedicellatis. Apertura genitalis.....Porus excretorius.....Piscium marinorum ecto-

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1). F. S. Leuckart—Versuch einer naturgemässen Eintheilung der Helminthen nebst dem Entwurf einer Verwandtschafts- und Stufenfolge der Thiere überhaupt. Heidelberg, 1827. I make the above quotation on the authority of Braun (Würmer, p. 334).

2). Diesing—Systema helminthum, vol. I, 1850. pp. 417 & 421.

3). This was slightly improved in his “Revision der Myzhelminthen” (p. 383) as follows: “Corpus subovale v. sublanceolatum depressum. Caput collo continuum, subtus acetabulis duobus juxtapositis. Os subterminale. Plectana octo pedicellata in postico corporis margine,

parasita." Although in these diagnoses the only point of difference of some generic importance observed by the author seems to have been the pediculate condition of the posterior suckers of the one in contradistinction to those of the other, yet most of the species known to Diesing and placed by him respectively in the two genera are precisely those which, though I have not been able to study them personally, still judging from the descriptions of others, I should bring just under those two genera in which they are respectively included by him. Thus there can be no doubt on the one hand that *O. scomбри* (Kuhn), one of the two species described by Diesing, is to be included in this genus as I have characterised it below. On the other hand, *Diclidophora Merlangi* (Kuhn) is, to judge from its (incomplete) descriptions given by Dieckhoff,<sup>1)</sup> in all probability to be included under *Diclidophora* as defined below, while as to *D. palmata* (Leuck.) there can be no doubt, from the general form of its body, of its belonging to the same genus. As to *Octocotyle lanceolata* (F. S. Leuck.) there is no doubt from its descriptions given by Dieckhoff<sup>2)</sup> that it is to be brought under another genus, the most salient point of difference being the presence of a dorsal vagina. I have, however, adopted Diesing's nomenclature, as he seems to be the first who has recognised the difference of the two genera under question. P. J. v. Beneden and Hesse also have noticed this difference and included them under two genera, *Octocotyle* and *Pterocotyle*; the latter being co-extensive with our *Diclidophora*, as may be seen from the following diagnosis given by the authors: "Huit ventouses portées sur de longs pédoncules unis à la base terminent le corps en arrière. Le ver est régulièrement effilé en avant, large vers le milieu et rétréci vers l'origine des ventouses. La bouche est flanquée de deux ventouses et une couronne de crochets entoure l'orifice des organes sexuels." Like Diesing these authors regarded the unimportant pedicels of the posterior suckers as of generic value; but their idea is capable of a surer foundation, as may be seen from the diagnoses of the two genera given below.

The name *Octostoma* was proposed by Kuhn in 1829; but like most writers

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singulum quadrivalve, valvulis semicircularibus, membranaceis, limbo corneo cinctis, asserculatis, in cardine transverso mobilibus. Androgyna; apertura genitalis mascula.....feminea antrorsum sita, uncinulorum corona simplici cincta. Poras excretorius.....Tractus intestinalis bieruris, coecus.—Ovipara, ovulis utraque extremitate appendice filiforme crasso.—Piscium marinorum ectoparasita." The penis is evidently mistaken for the female genital opening.

1). Dieckhoff—l. c. p. 265.

2). Dieckhoff—l. c. p. 255.

he included in it the forms which I hold to require separation into two genera.

The genus *Octocotyle* I propose to characterise as follows:

Body lanceolate, usually thick<sup>1)</sup>; anterior end obtusely triangular, posterior end rounded. With a single pair of ellipsoidal anterior suckers inside the mouth, and with four pairs of posterior, somewhat bean-shaped suckers on the ventral side at the posterior end of the body. With one or two pairs of hooks between the last pair of posterior suckers. Without a vagina. With a penis consisting of a median, cup-shaped body with a thick wall, which is perforated by the vas deferens, and an accessory, bean-shaped body attached to it on each side; all three bearing hooks on their inner surface.

1. *Octocotyle major*, n. sp.

(Pl. IX, figs. 1-6.)

Body lanceolate and thick<sup>2)</sup>, about 4 mm. long, the anterior part free from the vitellarium very short; *posterior suckers* small, being about<sup>3)</sup> 0.045 mm.  $\times$  0.038 mm., and arranged close to the lateral margin of the body. With only one pair of large *hooks* between the hindmost pair of suckers. The hook with a process at the middle of its length, its distal half enclosing a narrow cavity within (Pl. IX, fig. 2), and its proximal portion striated lengthwise; the latter appearance being due to the presence of longitudinal furrows on its surface; length of the hook 0.1 mm., the curvature not taken into account.

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1). The term "depressum" I find to be wholly inappropriate to the species observed by me.

2). In the figure the body seems flatter and broader than it is in reality, owing to the pressure of the cover-glass to which the specimen was subjected when killed.

3). The length of the posterior sucker has been measured parallel to the arms of the U-shaped chitinous piece, and its breadth at right angles to the same.

*Oesophagus* rather short ; the main trunks of the *intestine* wholly distinct from each other ; sending out lateral branches both outwards and inwards, those of the inner side, however, being a little shorter than those of the outer ; the trunks terminating a little in front of the foremost pair of posterior suckers. Common *genital opening* at the hinder end of the anterior portion of the body free from the vitellarium ; *penis spines* short, recurved, arranged in five pairs ; each spine consisting of a slender, spinous portion and a basal, lens-shaped portion. Diameter of the central bulb of the *penis* about 0.035 mm.; length of the lateral bulb 0.027 mm. *Ovary* long, U-shaped, with the open end directed forwards and the two arms of the U closely apposed to each other ; the oviduct end occupying the median line of the body and the other end situated more to the right. *Oviduct* after proceeding from its origin a short distance forwards turns backwards and a little towards the left, and is continued into the ootyp, which is situated just in front of the ovary a little on the left side. From the ootyp the *uterus* proceeds straight forwards. *Genito-intestinal canal* arising from the oviduct just before the ootyp, and thence proceeding forwards and slightly towards the right, opens into the intestine at the same level as the paired yolk-ducts. The *vitellaria* of the two sides are quite distinct behind but less so in front. The *paired yolk-ducts* are very short and unite with each other on the median line, about half as far from the anterior end of the ovary as from that of the body. The *unpaired yolk-duct* proceeds straight backwards, and opens into the oviduct side by side with the genito-intestinal canal but nearer the ootyp. *Testes* comparatively few in number, small ; the anterior ones arranged in a single row on the left side of the ovary ; the whole testes extending from a little behind the front end of the ovary to about midway between its hinder end and the termination of the intestinal trunks. *Vas deferens*

proceeding forwards from the foremost testis dorsally to the uterus.

*Habitat*—Gill of *Scomber colias* (Jap. Saba).

*Locality*—Misaki.

*Date*—December 1889.

2. *Octocotyle minor*, n. sp.

(Pl. IX, figs. 7-13.)

*Body* lanceolate, thick, about 2 mm. long, narrow anteriorly but broader posteriorly; the anterior portion free from the vitellarium long, separated from the hinder part by a slight constriction, and becoming gradually narrower towards the front end. *Posterior suckers* small, a little broader than long (being 0.03 mm.  $\times$  0.037 mm.), arranged in a straight line parallel to the median line of the body; the hindmost pair being close to the margin of the body and the anterior ones more removed from it. With two pairs of *hooks* at the posterior end of the body between the hindmost pair of suckers; the outer pair stouter, about 0.037 mm. long (curvature not reckoned), wholly solid, and with a process near the proximal end; inner pair filiform and curved, about 0.02 mm. (curvature reckoned). *Oesophagus* longer than in *O. major*; main trunks of the *intestine* completely separate from each other and reaching the foremost pair of posterior suckers; each sending out lateral branches both outwards and inwards, the inward branches, however, being very short. Common *genital opening* midway between the pharynx and the posterior end of the oesophagus. *Penis spines* long, arranged in six pairs, the foremost and longest ones being curved almost semi-circularly; each hook consisting of a long, slender, spinous, distal portion and a lens-shaped, basal portion attached to the penis bulb; diameter<sup>1)</sup> of the central penis bulb about 0.05 mm., length

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1). Too much specific value must not, however, be placed on these figures; for in another

of the accessory bulb 0.032 mm. *Ovary* long, U-shaped, with the open end directed forwards, and with the two arms of the U closely apposed to each other; the end containing the young ova once more bent on itself; the larger arm situated on the left side of the smaller, and occupying nearly the median line of the body. *Vitellaria* of the two sides nearly distinct both in front and behind. Relative disposition of the genital ducts same as in *O. major*. *Testes* more numerous than in *O. major*; the anterior ones extending as far anteriorly as the front end of the ovary, and arranged in a single row on its left side; the posterior ones extending about two-thirds the distance between the posterior end of the ovary and the foremost pair of suckers.

*Habitat*—Gill of *Scomber colias* (Jap. Saba).

*Locality*—Hagi and Misaki.

*Date*—August 1889 (Hagi), Dec. 1889 (Mis.).

I believe there is no doubt that the species above described are new, although they inhabit the same host as *O. scomberi* (Kuhn). I at first suspected that the two species might have been confounded with each other and described as a single species by European writers, the contradictory statements of v. Beneden and Hesse<sup>1)</sup> on the one hand and St.-Remy on the other as to the number of the penis spines of *O. scomberi* seeming in some degree to favour such a view. But the hooks at the posterior end of the body of both the species here described are entirely different in form from those of *O. scomberi*,

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individual, that represented by fig. 12, I found the diameter of the central bulb to be only 0.035 mm.

1). P. J. v. Beneden and Hesse state them as being ten in number (*Recherches sur les Bdelloides et les Trématodes marins*, p. 97), while according to St.-Remy they are twelve (*Synopsis des Trématodes monogènes*, p. 32).



as may be seen from a comparison of my figures of the former with those of the latter given by Parona and Perugia.<sup>1)</sup>

#### IV. DICLIDOPHORA, Diesing (1850).

Body flat and of various forms, but generally speaking leaf-shaped; with a pair of spherical anterior suckers in the mouth-cavity and with four pairs of hemispherical (in a surface view circular) or slightly semi-ellipsoidal suckers arranged in a semicircle or horse-shoe shape at the posterior end of the body; each sucker often provided with a more or less long pedicel, and having a chitinous, supporting frame-work, the general structure of which is represented in fig. 1, Pl. XII. Intestinal trunks of both sides usually uniting with each other at the posterior end of the body, and besides connected with each other by numerous commissural branches. Penis spherical, perforated by the vas deferens, with a certain number of hooks of the general shape drawn in figs. 7 & 10, Pl. X, and arranged in a circle. Without vagina.

##### 1. *Diclidophora smarís* (Ijima, Ms).<sup>2)</sup>

(Wood-cut 1.)

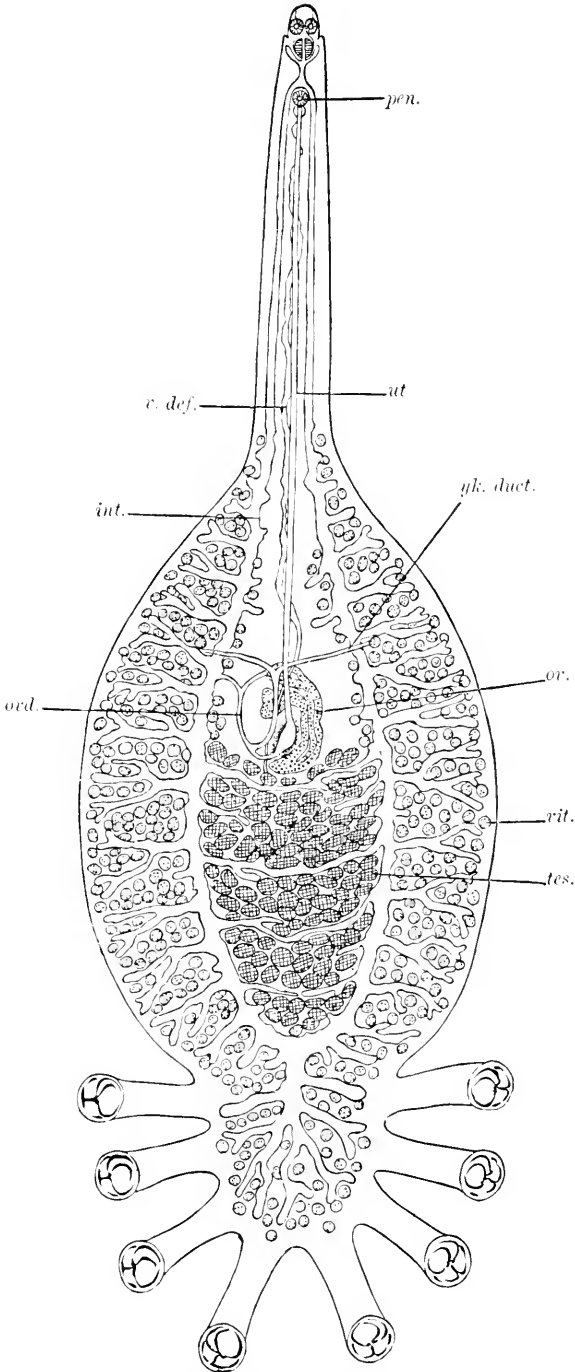
Synonym: *Octobothrium smarís*, Ijima.

*Body*  $6\frac{1}{3}$ -8 mm. long, separable into three parts, a slender, narrow, anterior portion, a broad, oval, leaf-shaped, middle portion, and a

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1). Parona e Perugia—Res ligusticae, VIII. Di alcuni trematodi ectoparassiti di pesci marini. Annali d. Museo Civico d. Storia Naturale di Genova. Ser. 2, vol. VII, p. 742.

2). This is the species which has been supposed by Dieckhoff to be identical with *Octobothrium Merlangi* (l. c. p. 250).



Wood-cut 1.—*Diclidophora smaris*, Ijima. Reproduced after a Drawing by Prof. Ijima.

small caudal disc bearing on its margin the tolerably long pedicels of the circular posterior suckers. The anterior portion which is, roughly speaking, a little less than one-third the total length of the body, is 0.25–0.30 mm. broad in the middle part, and in some specimens a circular folding of the surface of the body was present just in front of the pharynx. The middle portion measures, where it is broadest, *viz.*, a little behind the ovary, 2.25 mm. The caudal disc is at its anterior end about 1.00 mm. wide. The first pair of sucker-pedicels lies in a straight line at right angles to the long axis of the body, and the rounded angles between each two successive pedicels are equal to one another; the pedicels are cylindrical.

*Oesophagus* short; anterior portion of the intestinal trunk destitute of lateral branches, but the remaining portion sending out numerous lateral branches both inwards and outwards; those of the inner side posterior to the ovary uniting with those of the opposite side and forming commissures. From the point of union of the two intestinal trunks a single median trunk proceeds backwards; this, however, is very short and soon breaks up into a few secondary branches. Common *genital opening* situated about  $\frac{1}{2}$  mm. behind the mouth; *penis* with six hooks of the usual shape in this genus. *Ovary* situated in the median line, about the middle of the whole length of the body, long, bent on itself by its middle, and the whole curved, the long axis of the ovary roughly coinciding with that of the body. *Oviduct* arising from the anterior end of the ovary on the right side of the body, thence proceeding backwards and, curving inwards toward the median line, is continued into the ootyp, which is situated in the median line of the body just in front of the posterior end of the ovary. From the ootyp the *uterus* proceeds straight forwards. *Genito-intestinal canal* rather short, opening into the oviduct half as far from the beginning of the oviduct as from the ootyp, thence proceeding towards the right, and finally opening into the intestine. *Vitellaria* of the two sides distinct in front but continuous behind. *Paired yolk-ducts* of the two sides symmetrically disposed at right angles to the long axis of the body, and uniting with each other in the median line. *Unpaired yolk-duct* opening into the oviduct about half as far from the ootyp as from the opening of the genito-intestinal canal into the oviduct. *Testes* numerous, all situated behind the ovary; vas deferens running dorsal to the uterus and usually making some convolutions.

*Habitat*—Mouth-cavity of *Smaris vulgaris* (on the caudal segment of a *Cymothoa*).<sup>1)</sup>

*Locality*—Gulf of Naples. Collected by Dr. Max v. Brunn.

*Date*—Not recorded.

2. *Diclidophora elongata*, n. sp.

(Pl. X, figs. 9-10; Pl. XI, fig. 8; Pl. XII, figs. 1-2.)

*Body* lanceolate, anteriorly rather pointed, about 8 mm. long, the pedicel of the hindmost pair of suckers inclusive, divisible only into two parts, the body proper and the caudal disc, the latter being only about one-sixth the total length, and bearing on its margin the long pedicels of the circular *posterior suckers*; pedicels making equal angles with each other, and each containing in its proximal half a branch of the intestine and a portion of the vitellarium surrounding the former. *Oesophagus* very short. The two *intestinal trunks* sending out not very long lateral branches outwards, and connected with each other by cross-commissures, which unite with each other by means of secondary commissures; the trunks continued into each other at the posterior end of the body, thus forming here a loop. From the loop are sent out at regular intervals eight, somewhat long lateral branches, each of which penetrates into the pedicel of the sucker as above mentioned. Common *genital opening* close behind the termination of the oesophagus. *Penis* with eight hooks. *Ovary* occupying the posterior end of the middle third of the body, long, cylindrical, bent on itself once at its middle and the whole again bent on itself at its middle, so that the ovary has the form of a double V one placed within the other; with the angle of the V

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1). On this head Prof. Ijima remarks; "Ich glaube jedoch, dass sie nicht als Parasit jenes Schmarotzer-Krebsses, sondern vielmehr als derjenige des den letzteren beherbergenden Fisches anzusehen ist" (MS).

directed towards the left side of the body, and the whole lying more to the left than to the right of the median line. *Oviduct* arising from the front end of the larger half of the ovary, thence proceeding for a short distance forwards and towards the left, and then bending on itself and retracing its course, proceeds backwards, and approaching the posterior end of the body bends towards the right, and is continued into the ootyp, which is therefore situated on the right side of the body at a short distance from the trunk of the intestine. *Oviduct* bearing a tolerably large, round *receptaculum seminis* at its foremost end where it bends on itself. From the ootyp the *uterus* at first proceeds forwards and towards the left side of the body, and reaching the angle of the smaller (inner) half of the ovary, bends slightly towards the right, and then proceeds straight forwards. *Vitellaria* of the two sides distinct in front but continuous behind. *Paired yolk-ducts* slightly asymmetrical, that of the left side being situated a little anterior to its fellow; the ducts directed obliquely across the long axis of the body, and uniting with each other on the same level as the front end of the smaller half of the ovary. The *unpaired yolk-duct* thence proceeds backwards and slightly towards the left, and reaching the angle of the V-shaped ovary, bends on itself and proceeds towards the right side, and finally opens into the oviduct. *Genito-intestinal canal* arising from the oviduct a little anterior to the opening of the unpaired yolk-duct, proceeds forwards, and towards the right opens into the intestine. *Testes* numerous, rather small, extending from a little behind the ootyp to the level of the peliels of the foremost pair of suckers.

*Habitat*—Mouth-cavity of *Pagrus tumifrons* (Jap. Tai). Sometimes on the *Cymothoa* parasitic in the mouth-cavity.

*Locality*—Mogi (near Nagasaki) and Hakodaté.

*Date*—July 1889 (Mogi) and August 1890 (Hako.).

This species is evidently closely allied to *Octobothrium palmatum*, F. S. Leuck.

3. *Dididophora sessilis*, n. sp.

(Pl. X, figs. 5-8; Pl. XI, figs. 1-7; Pl. XII, figs. 3-4.)

*Body* about 5 mm. long, elongated-oval, generally broad but narrower in front, anterior end obtuse, divisible into the body proper and the caudal disc, which are separated from each other by a sharp constriction. Body proper leaf-shaped, occupying a little less than three-fourths of the total length; caudal disc small, bearing the circular sucker on its margin. *Suckers* sub-sessile, arranged in a semicircle close to each other. *Oesophagus* exceedingly short. The two *intestinal trunks* sending out lateral branches outwards, connected with each other by anastomosing commissures, and uniting with each other at the level of the first pair of posterior suckers; from this intestinal loop backwards are given off numerous branches which reach the base of the suckers. Common *genital opening* close behind the termination of the oesophagus. *Penis* with six hooks. *Ovary* occupying the middle of the body, long, twice folded on itself in the form of a W; the last arm of the W, which gives rise to the oviduct, is hollow, very much larger than the others, and is situated farthest to the left. *Oviduct* arising from the large end of the ovary, proceeds at first for a short distance towards the right, then bends, and after proceeding backwards for some distance bends forwards and towards the left, then again bends towards the left, and reaching the right angle of the W-shaped ovary, is continued into the ootyp. Oviduct bearing an exceedingly large *seminal receptacle* consisting of numerous lobes at the point where it bends forwards to unite with the yolk-duct. From the ootyp the *uterus* proceeds at first forwards and towards the right, and reaching the median line of the body, pro-

ceeds straight forwards towards the common genital opening. *Paired yolk-ducts* slightly asymmetrical, making an angle with the long axis of the body, and uniting with each other on the same level as the fore end of the ovary. The *unpaired yolk-duct* thence proceeds backwards and towards the left, and unites with the oviduct in the median line of the body, just where the oviduct bends to the left towards the ootyp. *Genito-intestinal canal* tolerably long, and arising from the oviduct side by side with the *receptaculum seminis*, proceeds slightly forwards and towards the right, and finally opens into the intestine. *Testes* exceedingly numerous, tolerably large, extending from a little behind the common genital opening to the level of the first pair of posterior suckers, and occupying the whole region enclosed by the two intestinal trunks, *i. e.*, three-fifths of the total breadth of the body. *Vas deferens* as usual on the dorsal side of the uterus.

*Habitat*—Mouth-cavity of *Choerops Japonicus* (Jap. Kobu-dai or Kan-dai). Young specimens also on the gill.

*Locality*—Mitsugahama (Prov. Iyo).

*Date*—August 1889.

4. *Dictidophora tetrodonis*, n. sp.

(Pl. X, figs. 1-4.)

*Body* long and slender, spathulate, 5-15 mm. long, divisible into three portions, an anterior, fusiform portion a little over half the entire length of the body, a middle, slender, stalk-like portion half as long as the former, and the caudal disc a little less than half the stalk-like portion and bearing the suckers along its margin on the ventral side; the three portions, however, gradually passing into each other without any sharp demarcation. *Suckers* sessile, elliptical, arranged in a deep horse-shoe shape, the open end of which is directed forwards;

the four suckers of each side equidistant from each other, and those belonging to the last pair separated from each other slightly more than those of the same side are from each other. *Oesophagus* almost wanting. The two *intestinal trunks* sending lateral branches outwards, and connected with each other by sparsely anastomosing commissures only in the anterior, fusiform portion of the body ; in the stalk-like portion the two trunks also send out short lateral branches but run parallel to each other and remain wholly separate up to their terminations between the last pair of suckers. Common *genital opening* close behind the beginning of the intestine. *Penis* with ten hooks. *Ovary* comparatively small, occupying the median part of the body in the anterior half of the last third of the fusiform portion ; when viewed from the ventral side somewhat like two commas placed obliquely one above the other, with the upper one more to the right. *Oviduct* arising from the enlarged head of the anterior half of the ovary and thence proceeding backwards and slightly towards the right as far as the posterior end of the ovary, bends slightly towards the left, keeping its backward course, and reaching the front end of the testes in the median line, suddenly bends forwards and is continued into the ootyp. *Vitellaria* of the two sides distinct both in front and behind ; absent from the stalk-like portion. *Paired yolk-ducts* symmetrical, uniting with each other at about the hinder end of the foremost third of the whole body, dorsally to the uterus. The *unpaired yolk-duct* thence proceeds backwards and slightly towards the right, and reaching the level of the middle of the ovary, turns slightly towards the left, and reaching the level of the front end of the testes, bends rather sharply towards the right, and opens into the oviduct a short distance in front of the point where the latter bends forwards to meet the ootyp. From this the *uterus* proceeds forwards, and its anterior part sometimes contains numerous eggs, in consequence of which it is greatly enlarged and



swollen, giving rise to an elevated patch on the ventral side of the body. *Genito-intestinal canal* arising from the oviduct a little nearer its origin than the opening of the unpaired yolk-duct, proceeds forwards and a little towards the right, and finally opens into the intestine. *Testes* small, comparatively few in number, together forming a triangular patch behind the ovary, between the two trunks of the intestine; not extending into the stalk-like portion.

*Habitat*—Gill of *Tetrodon* sp. sp. (Jap. Kogomé-fugu and Kōyosé-fugu).

*Locality*—Hagi.

*Date*—August 1889.

Although this species presents conspicuous differences from the two foregoing species, there is no doubt that it is to be included in the same genus, both from the form of the penis and its hooks and the form of the sucker and its chitinous framework, as well as from some other less significant points of similarity. As to the chitinous frame-work of the suckers, it is to be remembered that, as already mentioned in the anatomical part, that of the first pair presents such a change in the relative position of the component pieces as to have to be regarded as having undergone a rotation of  $180^\circ$  on its own axis, the piece directed forwards in the other suckers being turned backwards in this. In fact this species represents an aberrant member of the genus.

## V. HEXACOTYLE, Blainville.

This genus was founded in 1828 by Blainville, and contains at present only a single species, which was first met with by De la Roche<sup>1)</sup> on the gill of *Scomber*

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1). De la Roche—Sur deux animaux vivants sur les branchies des poissons. Nouv. Bull. d. sciences d. l. soc. Philom., 1811., No. 14., 270-273. I cite this on the authority of Dujardin, Diesing, and Braun.

*thynnus* and described by him under the name of *Polystoma thynni*. Later it was described under the name of *Polystoma duplicata* by Rudolphi<sup>1)</sup> in his "Entozoorum synopsis." The diagnosis<sup>2)</sup> given by Blainville is as follows: "Corps ovale, deprime, continu ou non articulé, composé de deux parties; une antérieure, bien plus petite, subcylindrique, ridée; l'autre postérieure, beaucoup plus grande, ovale, alongée, déprimée et bordée inferieurement par trois paires de ventouses, armées à l'intérieur de deux petits crochets opposés. Tête petite, peu distincte, portant la bouche à son extrémité. Anus dorsal à la jonction du cou et du corps. Orifice des organes de la génération au même endroit en dessous." The "anus" above referred to is probably the opening of the vagina, which is very conspicuous on a surface view. In his "Histoire naturelle des Helminthes" Dujardin<sup>3)</sup> gives the following diagnosis of the species, for which he adopts the name given it by Rudolphi: "Corps grisâtre, mou et lisse, long de 12 à 16 mm., large de 3.4 mm., et elliptique au milieu, rétréci en avant, élargi en arrière, où se trouvent les six ventouses rangées transversalement, avec deux papilles intermédiaires;—bouche terminale;—ventouses bivalves, soutenues par plusieurs pièces cornées qui, en se rapprochant les font paraître divisées (*duplicata*)," a description differing only in a few points from that of Blainville, but in many respects more incomplete. Diesing<sup>4)</sup> in his "Systema helminthum" erected for the species a new genus *Plagiopeltis*, with the following diagnosis: "Corpus elongatum depressum. Caput corpori continuum. Os.....Acetabula ventralia octo in corporis parte dilatata marginalia, serie simplici disposita, elliptica planiuscula, marginata, singula acetabulum transverse ellipticum margine involutum, centrali minus, includentia. Genitalia externa.....Porus excretorius.....Piscium marinorum ectoparasita." A new addition to our knowledge of the genus contained in the above is the correct ascertainment of the number of posterior suckers (eight), the innermost pair of which is

1). Rudolphi—Entozoorum synopsis, 1819. pp. 125 & 133. Cited on the authority of Dujardin, Diesing, and Braun.

2). Blainville—Dictionnaire des sciences naturelles. T. 57, 1828. p. 570. Pl. XXVII, fig. 1. Cited on Braun's authority.

3). Dujardin—Histoire naturelle des helminthes, 1845. p. 318.

4). Diesing—Systema helminthum, p. 416. The diagnosis given in his "Revision der Myzhelminthen" (p. 363) seems to me scarcely an improvement.

much smaller than the others. Taschenberg,<sup>1)</sup> on the other hand, in a paper published in 1879, repeated the incorrect statements of the earlier writers as to the number of suckers. In 1890, however, Diesing's statement on this point was almost simultaneously confirmed by Monticelli<sup>2)</sup> on the one hand and Parona and Perugia<sup>3)</sup> on the other. So far as I know our knowledge of this genus has after all been very incomplete. The generic diagnosis I give is as follows:

Body flattened, elongated, broad in the middle portion, slender and subcylindrical in front, acutely pointed at the anterior end, broad and expanded behind; posterior margin forming two sides of an isosceles triangle, with a notch at the apex. With a pair of exceedingly small, spheroidal anterior suckers within the mouth. Posterior suckers elliptical; in four pairs close to the posterior margin, with their major axes directed at right angles to the margin; each with three chitinous supporting pieces arranged in a line on the major axis of the sucker; the innermost pair of suckers very much smaller than the others. With two pairs of hooks between the innermost pair of suckers. With a single, dorsal, median vagina. Common genital opening ventral and median.

*I. Hexacotyle acuta*, n. sp.

(Pl. XII, figs. 5-7; Pl. XIII, figs. 1-3; Pl. XIV, figs. 1-5.)

*Body* 11 mm. or more in length, divisible into three portions separated from each other by two broad constrictions, an anterior slender

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1). Taschenberg—Zur Systematik der monogen. Trematoden. Zeitschr. f. d. gesamm. Naturwissensch., 52. Bd., 1879, p. 232-265. Cited on Braun's authority.

2). Monticelli—Note elmintologiche. Boll. d. Soc. d. Natur. in Napoli. Ann. IV, 1890, fasc. II, p. 195. Cited on Braun's authority.

3). Parona e Perugia—Intorno ad alcune Polystomeae e considerazione sulla sistem. di questa famiglia. Atti del. Soc. Ligust. d. Scienz. Natur. e Geogr. Vol. I, fasc. III, 1890. Estratto, p. 15, foot-note.

portion which ends with a mucronate apex, a middle portion occupying about half the whole length of the body, and a posterior, broad portion mostly free from the vitellarium and carrying the *suckers* near its posterior margin. The innermost small pair of suckers situated in a line with the posterior halves of the others. Chitinous pieces of the suckers as represented in fig. 3, Pl. XIII. Inner pair of *hooks* solid, very much smaller than the outer, with strongly recurved, pointed end and bent almost at a right angle at the middle of their length, 0.03 mm. long if its middle bending be straightened out. Outer pair solid, strongly recurved at the end, with a large process a little distally from the middle of its length, 0.09 mm. long (curvature not taken into account); their forms as represented in fig. 2, Pl. XIII. *Oesophagus* single only for a short distance posterior to the small pharynx, and sending out numerous lateral, anastomosing branches during the remainder of its length. Two pairs of main *intestinal trunks* may be distinguished, the inner of which corresponds to those of other species and reaches the hinder end of the body; the outer on the other hand extends only for about two-thirds of the whole length of the body from a short distance behind the front end of the body close to the lateral margins. All the four trunks are connected with each other by numerous, closely anastomosing branches. Common *genital opening* near the hinder end of the anterior, slender portion of the body, just behind the beginning of the inner pair of intestinal trunks. *Ovary* median, at about the middle of the whole length of the body; its windings very complicated, as represented in fig. 1, Pl. XIV. *Oviduct* arising from the posterior right end of the ovary, thence proceeding backwards and towards the left side, and almost reaching the median line of the body suddenly turns dorsad and towards the right, and continuing its course for a short distance, again turns dorsad, anteriorad,

and towards the left, and is continued into the ootyp, which is somewhat long in this species, and lies near the dorsal side of the body with its length placed at right angles to the long axis of the body. The *uterus* proceeds from the left end of the ootyp forwards and slightly towards the right, and after reaching the median line of the body some distance in front of the ovary, proceeds straight forwards to the common genital opening. *Vitellarium* extending from the level of the vaginal opening to that of the posterior end of the testes. *Paired yolk-ducts* asymmetrically disposed on the two sides. That of the right side arises more in front than the other, a short distance in front of the origin of the oviduct; it at first proceeds perpendicularly to the long axis of the body towards the median line, where it suddenly changes its course and turns posteriorly and proceeding backwards with a few windings unites with its fellow of the other side just behind the ootyp. The yolk-duct of the left side on the other hand arises from the vitellarium wholly behind the ovary, and proceeding straight towards the median line of the body, there bends at right angles to its previous course and unites with its fellow coming from the front. The *unpaired yolk-duct* is short, and proceeds from the point of union of the paired yolk-ducts towards the right side, and opens into the oviduct at about the middle of its whole length. *Genito-intestinal canal* arising from the oviduct side by side with, and just in front of, the unpaired yolk-duct; the canal at first very small, but soon swollen into a voluminous *receptaculum seminis*, from the front end of which it again continues, and proceeding towards the right with a few convolutions, at last opens into the inner trunk of the intestine. *Vagina* dorsal, a little behind the genital opening, armed with conical teeth, and surrounded on both sides with a compact, refractive mass of connective tissue, in consequence of which the opening is often seen to have a swollen lip in specimens killed with hot sublimate; *vaginal*

canal at first single, but soon divides right and left into two canals, which then proceed backwards on the inner side of the inner intestinal trunks, and become continuous each with the paired yolk-duct of the same side. *Testes* tolerably numerous, of moderate size, situated between the inner pair of intestinal trunks behind the ovary, and extending to the constriction which divides the middle from the posterior portion of the body.

*Habitat*—Gill of *Thynnus sibi* (Jap. Shibi).

*Locality*—Hagi and Osatsubé (Hokkaidō, where it was collected by my friend, Mr. Nozawa).

*Date*—August 1889 (Hagi).

2. *Hexacotyle grossa*, n. sp.

(Pl. XIII, figs. 4-6; Pl. XIV, 6-7.)

*Body* flattened, elongated, thick, about 18 mm. long, divisible into three portions as in the preceding species, but the anterior slender portion with lateral swellings at a short distance from its front end and passing more gradually into the middle, broad portion, and with the hindmost portion shorter than in *H. acuta*. The innermost small pair of *suckers* situated in a line with the posterior borders of the other suckers. Chitinous pieces of the suckers as represented in fig. 6, Pl. XIII. Inner pair of *hooks* very much smaller than the outer, solid, with strongly recurved ends, bent at a right angle at the middle of its whole length, 0.04 mm. long if the middle bending be straightened out; outer pair entirely hollow, with a rather thin wall, with strongly recurved, pointed end, and with a large process at the middle of its length, 0.126 mm. long (curvature not reckoned); their forms as represented in fig. 5, Pl. XIII. *Oesophagus* and *intestine* disposed as in *H. acuta*, the only difference worth noting being that the inner pair of intestinal trunks converge at a short distance in

front of the suckers, and unite in the median line just in front of the innermost of the larger pair of suckers. Common *genital opening* a little in front of the anterior end of the median pair of intestinal trunks. *Ovary* in the median line, at about the middle of the whole length of the body, long, bent on itself like a loop, with numerous secondary convolutions, and with the open end of the loop directed backwards. The *oviduct* arises from the end of the right arm of the loop, thence proceeds backwards and towards the right, and after receiving the genito-intestinal canal turns backwards, and then making one or two convolutions, turns dorsad, and is continued into the ootyp, which is tolerably long, and lies with its length directed obliquely in an antero-posterior direction. *Uterus* taking a course as in *H. acuta*. *Genito-intestinal canal* arising from about the middle of the whole course of the oviduct, enlarged into a voluminous *receptaculum seminis*, from the anterior end of which the small convoluted canal proceeds forwards and towards the right, and finally opens into the inner trunk of the intestine. *Vitellarium* extending from the level of the vaginal opening to a short distance behind the posterior end of the testes. *Paired yolk-ducks* asymmetrically disposed with respect to each other; that of the right side arising from the vitellarium on the same level with the opening of the genito-intestinal canal into the intestine. The arrangement of the paired yolk-ducks with respect to each other and to the unpaired yolk-ducks as in *H. acuta*. The *unpaired yolk-duct* opening into the oviduct side by side with the genito-intestinal canal, but not so closely as in *H. acuta*. *Vaginal opening* dorsal, a short distance behind the common genital opening; the single *vaginal canal* soon dividing into two, which are disposed as in *H. acuta* and become continuous each with the paired yolk-duct of the same side. *Testes* numerous, of moderate size, posterior to the ovary, and ending a little in

front of the constriction which divides the middle from the posterior portion of the body.

*Habitat*—Gill of *Thynnus* sp. [Jap. Mebachi-maguro].

*Locality*—Misaki.

*Date*—August 1891.

Although we have no adequate description of *Hexacotyle thynni*, de la Roche, the only species of the genus hitherto described, I believe there is scarcely any doubt that the two species here described are new. Thus, in the first place, the general form of the body of both the species differs from that of *H. thynni* as figured by St.-Remy<sup>1)</sup> and Diesing<sup>2)</sup>; and in the second place, according to the statement and figure of the former writer, the larger pair of hooks is situated in front of the other, which is not the case in either of the species here described.

## VI. ONCHOCOTYLE, Diesing.

This genus is due to Diesing who erected it in his "Systema helminthum" (1850) for an ectoparasite found for the first time (1829) by Kuhn<sup>3)</sup> on the gill of *Squalus catulus* and described by him under the name of *Polystoma appendiculatum*. The same species was afterwards redescribed more at length by Nordmann<sup>4)</sup>, Thær<sup>5)</sup>, P. J. v. Beneden<sup>6)</sup>, and Taschenberg<sup>7)</sup>. In 1853 P. J. v. Beneden<sup>8)</sup> added a new species (*O. borealis*); in 1878 two more new species (*O. abbreviata* and

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1). St.-Remy—Synopsis. Pl. X, fig. 22.

2). This I cite on the authority of Braun, in whose "Würmer" the figure is reproduced (Pl. XII, fig. 8).

3). Kuhn—Description d'un nouveau genre de l'ordre des douves etc. Mém. d. mus. d'hist. nat. T. XVIII, 1829. Also in Annal. d. scien. d'observ., II, 1829. Both cited on the combined authority of Diesing, Dujardin, and Braun.

4). Nordmann—Mikrographische Beiträge, p. 80.

5). Thær—De Polystomo appendiculato, 1851. Also "Ueber Polystomum appendiculatum" in Müller's Archiv f. Anat. Phys. Jahrg. 1850. The latter is cited on Braun's authority.

6). P. J. v. Beneden—Mémoire sur les vers intestinaux. 1861. p. 54.

7). Taschenberg—Weitere Beiträge.

8). P. J. v. Beneden—Espèce nouvelle de genre Onchocotyle vivant sur les branchies du *Seymus glacialis*. Bull. d. l'Acad. roy. d. Belg., t. XX, 1853. p. 59. Cited on the authority of P. J. v. Beneden and Braun.



*O. emarginata*) were described by Olsson<sup>1)</sup>; and finally in 1890 a fourth species (*O. Prenanti*) was added to the genus by St.-Remy<sup>2)</sup>. Besides these there is according to Diesing<sup>3)</sup> another species not yet described but mentioned by Wagner in a note to a paper of his published in "Naturk. Verhand. Harlem, XIII," as living on the gill of *Scymnus ainosi*. This species is not mentioned either by Braun or St.-Remy, and I am not sure whether it will prove to be identical with some one of the species already described, or to belong to quite another genus.

The original diagnosis of Diesing is as follows; "*Corpus lineari-lanceolatum depressum, utrinque angustatum. Caput corpore continuum. Os subterminale. Acetabula sex disco elliptico extremitati caudali supra adnato, biseriatis immersa, hemisphaerica, margine uncino simplici inferna adnato apice libero armata. Aperturæ genitales.....Porus excretorius in apice caudali.*—*Piscium marinorum ectoparasita.*" This was improved in his "Revision"<sup>4)</sup> as follows: "*Corpus lineare-lanceolatum depressum, appendiculo caudali postico. Caput corpore continuum. Os subterminale. Acetabula sex, lamellae ellipticae, extremitati corporis posticae subtus adnatae, biseriatis immersa, hemisphaerica, margine uncino simplici inferne adnato, apice libero, armata. Androgyna; aperturæ genitales postpositae ventrales antrorsum sitae, medianae; penis vaginatus ante aperturam femineam situs. Pori excretorii duo in appendice caudali, terminales.*—*Tractus intestinalis biseriatis, caecus.*—*Ovipara ovulis utraque extremitate appendiculo filiformi instructis.*—*Piscium marinorum ectoparasita*"—a diagnosis which has been repeated in its essential points by subsequent writers, but which requires some modifications in accordance with the facts already mentioned in the anatomical part of the present paper. It has moreover been stated that in some species the caudal appendage does not bear any hooks near its extremity. This statement sounds somewhat anomalous to me; but as I am not able to re-examine the species in question, I shall leave the statement as it stands, and give the generic diagnosis as follows:

Body elongated, very thick, narrow towards both ends; anterior end blunt, and with a sub-ellipsoidal sucker

1). Olsson—Bilag til Scandinaviens helminthfauna. Kgl. svenska vetensk. Acad. Handl. N. F. XIV, 1878. p. 35. Cited on the authority of Braun and St.-Remy.

2). St.-Remy—Sur une espèce nouvelle de Polystomien du genre *Onchocotyle* Dies. Rev. biol. d. Nord de la France. III. ann., 1890. p. 41. Cited on the combined authority of Braun and St.-Remy.

3). Diesing—Revision der Myzhelminthen, 1858, p. 371.

4). Diesing—Revision, p. 370. The italics are mine.

around the mouth-cavity; with three pairs of circular or elliptical suckers at the posterior end, each with a semi-circular chitinous supporting piece with one of the ends provided with a claw. With a subcylindrical caudal appendage, which bears at its extremity a pair of small suckers destitute of any chitinous framework; often with a pair of hooks between these suckers. With a paired vaginal opening on the ventral side of the body. *Porus genitalis* ventral and median.

I. *Onchocotyle spinacis*, n. sp.

(Pls. XV & XVI.)

*Body* long-lanceolate, elliptical in cross-section, about 8 or 9 mm. long, with the anterior end roundly truncate. *Mouth* subterminal, ventral, with a large sucker around it like that of the distomes. The three pairs of large, slightly elliptical *posterior suckers* are arranged in a typical horse-shoe shape, with their mouths turned dorsad (but lying on the morphologically ventral side), each with a long semicircular chitinous piece with a narrow axial cavity throughout its length and with one of its ends pointed and curved in the form of a claw. These chitinous pieces lie in the suckers with their lengths parallel to the longer axes of the suckers. *Caudal appendage* subcylindrical, with a bifid extremity which carries a pair of small ellipsoidal suckers with their mouths opening at the top of either bifid end; with a pair of *hooks* 0.04 mm. long (curvature not reckoned) and of the form represented in fig. 5, Pl. XV, between the suckers; directed obliquely forwards towards the left side of the body. *Oesophagus* of moderate length. *Intestinal trunks* simple, uniting with each other at the level of the first pair of posterior suckers, and at this point giving out two simple branches, one of which is continued

backwards between the suckers, and the other enters the caudal appendage and ends a little before reaching the level of the small suckers at the extremity. *Genital opening* on the same level with the posterior end of the oesophagus, without any chitinous armature. *Ovary* long, with numerous windings (Pl. XV, fig. 1), situated near the hinder end of the anterior half of the body; of small size in relation to the whole body. The *oviduct* proceeds from its origin for a certain distance forwards with a few windings, and then sharply turns backwards and towards the right, and after proceeding posteriorly for a short distance, again turns sharply forwards and is continued into the *ootyp*. This is tolerably long and lies with its long axis nearly coinciding with that of the body. From its front end the *uterus* proceeds straight forwards toward the genital opening. *Vitellarium* extending from a little behind the anterior end of the intestinal trunks to the point of their union at the level of the first pair of posterior suckers; separate in front but continuous behind. *Paired yolk-ducts* perfectly symmetrical on the two sides, arising from the vitellarium at about the level of the front end of the last third of the anterior half of the whole body; proceeding at first somewhat forwards and towards the median line, then bending backwards, and uniting with each other in it to form a sort of vitelline reservoir. From this a small *unpaired yolk-duct* proceeds backwards and opens into the oviduct at the point where this turns sharply backwards towards the ootyp. The *genito-intestinal canal*, arising from the oviduct side by side with the unpaired yolk-duct, proceeds at first towards the right, then turns backwards and finally opens into the intestine. *Receptaculum seminis* situated on the right side of the median line just in front of the ovary, large, oval, with a long neck which opens into the oviduct side by side with the genito-intestinal canal. *Testes* numerous, of moderate size;

the anterior ones overlapping the posterior portion of the ovary ; ending behind at a distance from the first pair of posterior suckers equal to about the length of the caudal appendage.

*Habitat*—Gill of *Spinax* sp. (Jap. Tsubakurozame).

*Locality*—Odawara.

*Date*—February 1891.

## VII. CALICOTYLE, Diesing.

This genus was erected in 1850 by Diesing for a worm found by Kroyer on the surface of the body of *Raja radiata* near the anus and afterwards described and studied more minutely by Diesing<sup>1)</sup> himself, Hoek,<sup>2)</sup> and Wierzejski<sup>3)</sup>; and up to the present date it has contained only a single species, *Calicotyle Kroyeri*, Diesing. Its original diagnosis<sup>1)</sup> as given by its founder is as follows: "Corpus planum late obovatum. Caput corpore continuum. Os subterminale transverse ellipticum. Tractus intestinalis bifurcatus (?). Acetabulum basilare ventrale, ureceiforme septangulare intus dissepimentis septem a centro radiantibus. Aperturæ genitales infra os, approximatae. Anus.....Piscium marinorum ectoparasita." This was emended in his "Revision" as follows: "Corpus planum late obovatum. Caput corpore continuum. Os subterminale transverse ellipticum. Acetabulum unum subbasilare ventrale, ureceiforme, septangulare, intus dissepimentis septem e centro radiantibus, quinque inermibus uncino valido vaginato retractili armatis. Androgyna; aperturæ genitalium infra os oblique juxtapositæ approximatae. Porus excretorius.....Tractus intestinalis bicurvis, coecus.—Ovipara.—Piscium marinorum endo- et ectoparasita." The last remark was probably occasioned by the fact that *Calicotyle Kroyeri* was found by Hök in the anus as well as in the rectum. Subsequent diagnoses of the genus have been based on that of Diesing, which is no doubt in the main correct, but which I believe I can improve as follows:

Body flat, ovate, with a median notch at the pos-

1). Diesing—Vierzehn Arten von Bdelliden. Denkschr. d. k. Acad. d. Wiss. Wien., Bd. 14, 1858. p. 63-80. Cited on Braun's authority.

2). Hoek—Om *Calicotyle Kroyeri*. Oefversigt af. k. vet. Akad. Förhandl, 1856. Cited on the combined authority of Braun and Wierzejski.

3). Wierzejski—Zur Kenntniss des Baues von *Calicotyle Kroyeri*. Zeitsch. f. wiss. Zool., Bd. 59, 1877. p. 551.

4). Diesing—Syst. helm. p. 431 & 651.

terior end, at the apex of which is attached a large, circular, saucer-shaped sucker, the cavity of which is divided by means of elevated, radial spokes into a central heptagonal area and seven quadrangular, peripheral areas, the most posterior of which is larger than the others and occupies the median line of the body, while the rest is symmetrically disposed on the two sides. With a pair of hooks imbedded in the radial spokes that bound the hindmost peripheral area. Mouth subterminal and ventral, with a rudimentary sucker just behind it. With a paired vaginal opening on the ventral side of the body. Common genital opening median and ventral. With a tubular, chitinous penis.

1. *Calicotyle Mitsukurii*<sup>1)</sup>, n. sp.

(Pl. XIX.)

*Body* very flat, ovate, about 8 mm. long and 5 mm. broad. *Posterior sucker* sessile, large, having a diameter equal to about one-third the whole length of the body; with seven, small notches at the periphery corresponding to each radial spoke; central area of the sucker situated a little in front of the true centre of the sucker; the sucker projecting beyond the posterior end of the body proper by about one-third of its diameter. *Hooks* very stout, hollow in its distal portion equal to about one-fourth its whole length; strongly recurved at the end; of the form represented in fig. 5, Pl. XIX; 0.56 mm. long (curvature not reckoned). Anterior end of the body rounded; with two pairs of hollow, goblet-shaped *sticky glands* opening by their long necks at the anterior end on each side of the median

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1). Dedicated to Kakichi Mitsukuri, Ph. D., *Ryūgakuhakushi*, Professor of Zoology in the College of Science, Imperial University, Tōkyō.

line. *Mouth* at a short distance from the front end of the body, slit-like, with its length at right angles to the long axis of the body. The *anterior rudimentary sucker* very conspicuous in surface view. *Pharynx* ellipsoidal, with the internal tubular cavity coinciding with the smaller axis. *Oesophagus* almost wanting. The two *intestinal trunks* unbranched, distinct behind, running almost parallel to the lateral margins of the body, but each making a slight inward winding at the level of the ovary (at about the end of the anterior third of the whole body), and approaching towards each other at the posterior end just in front of the sucker. Common *genital opening* ventral and median, a little behind the middle of the anterior half of the body proper. *Chitinous penis* exceedingly long and twice bent on itself; with an obliquely cut extremity; about 0.59 mm. long. *Ovary* situated at the hinder end of the anterior third of the whole body, long, doubled on itself so as to form a loop with its open end directed towards the left side of the body, looping the right intestinal trunk, and with numerous smaller convolutions. *Oviduct* very short, with a portion of it expanded into a small *receptaculum seminis*. *Ootyp* of a rhombic form in longitudinal section. *Uterus* very short. *Vitellarium* confined to the lateral portion of the body outside the intestinal trunks; consisting of numerous, branching tubules; and extending from the level of the pharynx to that of the posterior sucker. The numerous tubules of the anterior and the posterior parts of the vitellarium of each side unite among themselves into a single duct, which traverses the length of the intestinal trunk, and just outside this, and uniting with its fellow coming from the opposite direction at the level of the anterior third of the body proper, forms the *paired yolk-duct*. This then runs straight towards the median line of the body, unites with its fellow of the opposite side, and forms the *unpaired yolk-duct*, which is exceedingly short and immediately opens into the

seminal receptacle. *Vaginal openings* in the lateral region of the body; about half as distant from the outer border of the intestinal trunk as from the lateral margin of the body; in a plane a little in front of that of the paired yolk-ducts. The *vaginal canals* proceed thence a little backwards and towards the median line, where they unite and form a single short duct, which then opens into the seminal receptacle side by side with the unpaired yolk-duct. *Testes* situated behind the ovary, numerous, closely packed, occupying nearly the whole mesial region of the body posterior to the ovary, and enclosed by the intestinal trunks.

*Habitat*—Cloaca of *Ithina* sp.? (Jap. Katasashi-zanué).

*Locality*—Mitsugahama.

*Date*—August 1889.

That the species above described is new can, I think, be hardly doubted, as it presents many differences from *C. Kroyeri*. To mention only one, the hooks of the present species are much longer than those of *C. Kroyeri*, the latter being, according to my own measurement, only 0.30 mm. long; and their forms are also different, as may be seen by comparing fig. 5 with fig. 14, Pl. XIX, the latter of which has been drawn from a specimen of *C. Kroyeri* brought back from Europe by Prof. Ijima and kindly lent me by him.

### VIII. MONOCOTYLE, Taschenberg.

This genus is due to Taschenberg who erected it in 1878 for an ectoparasite found by him on the gill of *Myliobates aquila* in Naples, and named by him *M. myliobatis*, which has remained, up to the present date, the only species of the genus. The somewhat imperfect description by Taschenberg<sup>1)</sup> is as follows: "Der Körper ist langgestreckt, von vorn nach hinten etwas erweitert, und trägt am hintern Ende

1). Taschenberg—Helminthologisches. Zeitschr. f. d. gesamm. Naturwiss., Bd. 51, 1878, p. 562. Cited on the combined authority of Braun on the one hand and Parona and Perugia on the other.

einen ziemlich grossen sitzenden Saugnapf. Derselbe besitzt acht Speichen, von denen die eine in der Längsachse des Thieres gelegen ist, während jederseits drei vom Centrum nach der Peripherie hin ausstrahlen. Da wo die beiden letzten den Rand des Saugnapfes erreichen, sind zwei grosse, starke Chitinhaken eingefügt, die in der Querachse desselben gelegen sind. Die Mundöffnung am vordern Körperende ist sehr weit und dient gleichfalls zum Ansaugen. Die Länge des Thieres beträgt 5 mm. bei einer Breite von 2 mm. Der Saugnapf hält 1.5 mm. in Durchmesser. Die Farbe ist weisslich." Later in 1890 Parona and Perugia<sup>1)</sup> published a short anatomical description of the same species, confining themselves, however, from want of material, to the consideration of the sucker as well as some parts of the genital organs. Many of their statements, however, seem to me so anomalous and are in many important respects so at variance with the results of my own studies as set forth in the anatomical part of the present paper that I have thought it advisable to base myself only on my own observations in forming the diagnosis of the genus, which I believe I can best embody in what follows:

Body elongated, flattened; with a large circular, sessile, sub-basilar, posterior sucker, the internal surface of which is divided by means of eight radial spokes meeting at the centre into as many equal secants. The posterior radial spokes lying on each side of the median line carry each a large hook. Mouth large, subterminal, ventral, destitute of any sucker. With three testes. Common genital opening ventral and median. Vaginal opening ventral and lateral. With two pairs of eye-spots.

*I. Monocotyle Ijima*<sup>2)</sup>, n. sp.

(Pls. XVII & XVIII.)

*Body* about 3 mm. long, elongated, flattened, but not very broad; posteriorly pointed; gradually becoming narrower in front and

1). Parona e Perugia—Di alcuni trematodi ectoparassiti di pesci adriatici. *Annali del Mus. Civ. di Storia Naturale di Genova*. Ser. 2, vol. IX, 1890. Estratto pp. 5-8.

2). Dedicated to Isao Ijima, Ph. D., *Riyakushi, Riyakuhakushi*, Professor of Zoölogy in the College of Science, Imperial University, Tōkyō.



ending with a slight lateral expansion. Anterior end with a large, not very deep notch. With four pairs of *sticky glands* on each side of the notch. *Sucker* circular, sub-basilar, with a short stalk, with a diameter equal to about one-third the length of the body proper, provided with a marginal membrane; every two of the radial spokes lie in a line, and one of these pairs coincides with the median line of the body. The marginal membrane as well as the radial spokes carrying numerous minute *chitinous bodies* on their free surface. At the centre of the sucker where the radial spokes all meet together is left a small cup-shaped hollow area. *Hooks* large, strongly recurved at the end, and with a sort of conspicuous barb; 0.12 mm. long (curvature not taken into account). *Mouth* large, at a short distance from the anterior end of the body, with a capacious funnel-shaped cavity. No anterior sucker, but with the dorso-ventral musculature around the mouth specially developed and serving as a sucker. *Pharynx* typically egg-shaped, large. *Oesophagus* exceedingly short. *Intestinal trunks* simple, tubular, describing a few windings, and ending just behind the anterior end of the sucker, in the median line, close to each other but separate. Common *genital opening* about as far behind the posterior end of the pharynx as the total length of the latter; with a tubular *chitinous penis* making a single spiral winding, about 0.18 mm. long. *Ovary* situated a little in front of the middle of the whole body, long, large, and globular at its proximal end (*i.e.* the formative zone) but slender towards its distal end, twice forming a loop, and the more distal loop embracing the intestinal trunk of the right side. The *oviduct* proceeds from its origin at first forwards and towards the left, and after receiving the yolk-ducts and the vaginal canal, it sharply turns back towards the right, keeping its forward course, and is continued into the *ootyp.* This with its thick wall is very large and conspicuous, and opens directly into the

genital atrium. *Vaginal opening* on the left side of the body, a little behind the common genital opening and on the same plane with the anterior end of the ootyp, surrounded with a mass of compact connective tissue; *vaginal canal* short and leading into a spacious, globular *receptaculum seminis*, from which a short canal proceeds backwards and opens into the oviduct side by side with the yolk-duct. *Vitellarium* mainly confined to the lateral areas of the body outside the intestinal trunks, extending from about the plane of the front end of the pharynx to that of the termination of the intestinal trunks. The vitellarium of each side gives rise to two yolk-ducts which, coming one from the anterior and the other from the posterior part, unite just inside the intestinal trunks and give rise to the *paired yolk-duct*. This then proceeds straight towards the median line and opens into the oviduct at the point above specified, side by side with its fellow of the opposite side. *Testes* posterior to the ovary, large, three in number; one being situated behind in the median line and globular in form; the other two just in front of this and closely appressed to each other as well as to the posterior testis, so that the boundary separating the three has the form of  $\lambda$ . *Vas deferens* arising from the anterior testis of the left side, proceeding forwards just inside the left intestinal trunk to about midway between the common genital opening and the hinder end of the pharynx, then turning backwards on the right side, and making one or two convolutions, reaches the front end of the ootyp. Here it again turns forwards and passing through the *bulbus ejaculatorius*, opens finally at the base of the tubular chitinous penis.

*Habitat*—Mouth-cavity of *Trygon pastinaca* (Jap. Aka-ci).

*Locality*—Hiroshima (Ujina Port).

*Date*—August 1889.

## IX. EPIBDELLA, Blainville.

An excellent summary of the history of this genus up to 1861 is found in P. J. v. Beneden's "Mémoire sur les vers intestinaux" (pp. 18-21), and I have nothing to add to it. It has been already pointed out by Braun<sup>1)</sup> that Diesing's genus<sup>2)</sup> *Benedenia* is based without any sufficient ground on *Epibdella sciaenae*, P. J. v. Beneden. In 1889 a new species *E. Hendorffii* (= *Phylline Hendorffii*, Linstow<sup>3)</sup>) was described, so that the genus contains at present three species, *viz.*, the one just mentioned from the surface of the abdomen of *Coryphaena hippurus*, *E. hippoglossi*, O. Fr. Müller from the body surface of *Pleuronectes hippoglossus*, and *E. sciaenae*, P. J. v. Beneden from the body surface of *Sciaena aquila*.

P. J. v. Beneden<sup>4)</sup> gives the following diagnosis of the genus: "Corps de forme ovale, mince et aplati; tête pourvue de deux ventouses, une grande ventouse en arrière armée de crochets et couverte en dedans de papilles régulièrement disposées, avec le bord frangi; les orifices sexuels situés sur le bord à droit près de la ventouse buccale; deux vésicules pulsatiles, s'ouvrant en avant, à quelque distance du bord. Ils vivent sur la peau des poissons"—a diagnosis which has been reproduced in essence by subsequent writers. I believe I can improve it as follows:

Body flat, thin, more or less oval; with a pair of elliptical or circular suckers at the anterior end of the body on either side of the mouth, and with a circular or elliptical sucker at the posterior end. The posterior sucker destitute of any septa, and with three pairs of hooks near its posterior border. Mouth subterminal. Common genital opening ventral, on the left side of the body, just behind one of the anterior suckers, and near the margin of the body. Vaginal opening ventral, on the same side as the common genital opening, and

1). Braun—Würmer, p. 518.

2). Diesing—Revision d. Myzhelminthen, p. 363. Nachträge u. Verbeper. z. Rev. d. Myzhelm., p. 19.

3). Linstow—Beitrag z. Anat. v. Phylline Hendorffii. Archiv f. mik. Anat. Bd. 33, 1889. pp. 153-180.

4). P. J. v. Beneden—Mémoire etc. p. 18.

behind it at various distances. With conico-cylindrical or club-shaped penis. Testes two. With two pairs of eye-spots.

1. *Epibdella Ishikawae*<sup>1)</sup>, n. sp.

(Pl. XXVI, figs. 1-3.)

*Body* elongated-oval, flat, about 4 mm. in length. *Anterior suckers* nearly circular, connected together by a thin, membranous continuation of the anterior end of the body. *Posterior sucker* circular, with a marginal membrane; with three pairs of flattened *hooks* of the form represented in fig. 2, Pl. XXVI, in its posterior half. *Mouth* small, a little in front of the plane of the posterior end of the anterior suckers. *Oesophagus* wanting. *Intestinal trunks* with lateral branches, separate behind, ending at the plane of the front end of the posterior sucker. Common *genital pore* close to the left lateral margin of the body, at the plane of the mouth, just outside the anterior sucker; leading into a deep genital atrium, in which lies the long, conico-cylindrical *penis*. *Ovary* comparatively small, globular, situated in the median line, a little in front of the middle of the body proper. *Oviduct* arising from the ventral side of the anterior end of the ovary, thence proceeding forwards with a few slight windings and continued into the ootyp a little behind the posterior end of the penis. The *ootyp* is rhombic in horizontal section, and opens into the genital atrium by means of an exceedingly short neck. *Vitellarium* extending from the level of the front end of the pharynx to about the anterior end of the posterior sucker; that of the two sides intermingling with each other behind the testes. *Paired yolk-duct* of each side formed by the union of two ducts coming

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1) Dedicated to Chiyo-matsu Ishikawa, Ph. D., *Riyakushi, Iiyakuhakushi*, Professor of Zoölogy in the College of Agriculture, Imperial University, Tōkyō.

respectively from the anterior and posterior portions; proceeding towards the median line, and uniting with its fellow of the opposite side at the front end of the ovary a little to the left of the median line. *Unpaired yolk-duct* very short, proceeding from the point of union of the paired yolk-ducts straight to the oviduct. *Vaginal opening* a short distance behind the common genital opening, nearly on the same longitudinal line; *vaginal canal* long, making numerous convolutions and opening into the yolk-duct at the point of union of the paired ducts of the two sides. *Testes* large, two in number, paired, irregularly ellipsoidal, situated just behind the ovary. A single short *vas efferens* arising from each testis, immediately uniting with the other and forming the *vas deferens*. This proceeds forwards with numerous complicated convolutions as represented in fig. 3, Pl. XXVI, and finally entering the penis at its base and traversing nearly its whole length finally opens near its apex. *Prostate gland* very large, vesicular, elongated, just behind the penis.

*Habitat*—Gill of *Lethrinus* sp.? (Jap. Kuchibi-dai).

*Locality*—Hagi.

*Date*—August 1889.

## 2. *Epibdella ovata*, n. sp.

(Pl. XXVI, figs. 4-8.)

*Body* squarish-oval, a little broader in the posterior part, flat, about 2 mm. long. *Anterior suckers* elliptical, connected with each other by a thin membrane. *Posterior sucker* elliptical, with its longer axis at a right angle to the long axis of the body, with a marginal membrane, with a pair of notches on its anterior and posterior margins, due to the insertion of muscular fibres at these points; with three pairs of *hooks* of the form represented in fig. 5,

Pl. XXVI. *Mouth* small, at the plane of the hinder end of the anterior suckers. *Oesophagus* wanting. *Intestinal trunks* with numerous lateral branches, terminating at the front end of the posterior sucker, widely separated from each other. Common *genital opening* near the left lateral margin of the body, a little in front of the hinder end of the anterior sucker; leading into a deep genital atrium, in which lies the club-shaped penis with its smaller end directed outwards. *Ovary* spherical, comparatively small, in the median line, at the end of the anterior third of the whole body. The *oviduct* arises at the anterior end of the ovary on the ventral side, and thence proceeds at first forwards, then turns backwards, and then again proceeds forwards, undergoing more or less convolutions on the way, and is finally continued into the *ootyp*, which opens into the genital atrium by means of a short duct, the uterus (*cf.* fig. 6, Pl. XXVI). *Vitellarium* extending from the level of the front end of the pharynx to the front end of the posterior sucker; the lobes of the two sides intermingled with each other behind the testes. *Paired yolk-ducts* directed transversely to the long axis of the body, that of the right side longer than its fellow of the opposite side; the two therefore uniting with each other on the left side of the ovary and there forming a capacious, globular *yolk-reservoir*, from which a short *unpaired yolk-duct* leads into the oviduct. *Vaginal opening* on the left side of the body, about midway between the common genital opening and the front end of the testes, surrounded by a mass of compact connective tissue. *Testes* large, ellipsoidal, paired, just behind the ovary. A single *vas efferens* arising from each testis, and uniting just in front of the testis of the left side. The *vas deferens* thence proceeds forwards with numerous complicated convolutions as represented in fig. 6, Pl. XXVI, and traversing the whole length of the penis finally opens at its apex. With a pair of *small globular bodies* behind the testes. *Prostate gland*

conspicuous, egg-shaped, hollow, with a thick wall, and communicating with the penis by means of a short, slender duct.

*Habitat*—Gill of *Anthias Schlegelii* (Jap. Akasagi).

*Locality*—Misaki.

*Date*—August 1891.

## X. TRISTOMUM, Cuvier.

This genus was created by Cuvier<sup>1)</sup> in 1817 for a worm found on the gill of various species of fish and named by him *T. coccineum*, a species which was afterwards examined and described more minutely by Taschenberg. Previous to Cuvier's erection of the genus, however, a worm of the same genus had been described (1786) by La Martiniere<sup>2)</sup>, the *T. maculatum* of Rudolphi. In 1836 a second species was described by Diesing and was named by him *T. papillosum*, a species which was afterwards made the object of a more minute study by Köllicker<sup>3)</sup> and Taschenberg<sup>4)</sup>; in 1847 two new species (*T. squali* and *T. molae*) were described by Blanchard<sup>5)</sup>; in 1878 *T. pelamydis* was described by Taschenberg<sup>6)</sup> and was afterwards redescribed somewhat more at length by Parona and Perugia<sup>7)</sup>, and more clearly distinguished from the other species; in 1889 a seventh species,

1). Cuvier—Règne animal, 1817, t. IV, p. 12. From the quotation in Braun's "Würmer" (p. 528) it appears that Cuvier at first mistook the anterior end for the posterior, but in a later edition the mistake is corrected (cf. Règne animal, t. III, Paris, 1839, p. 265).

2). Martinière—Journ. d. physique, 1787, p. 207. Also in "Voyage de Lapérouse," 1798, t. IV, p. 79. Cited on the combined authority of Dujardin, Diesing, and St.-Remy.

3). Köllicker—Ueber Tristomum papillosum Dies. Berichte von d. k. k. zool. Anstalt z. Würzburg, II. Ber. f. d. Schuljahr 1847/48, 1849, pp. 21-27. Cited on Braun's authority.

4). Taschenberg—Beiträge z. Kenntniss mar. ectopar. Trematoden, 1879.

5). Blanchard—Recherches sur l'organisation des vers. Annales d. sciences natur., 3. ser., VIII, 1847. Cited on the combined authority of Braun and St.-Remy.

6). Taschenberg—Helminthologisches. Zeitsch. f. d. gesamm. Naturwiss., 1878, p. 562-577. Cited on the combined authority of Braun and St.-Remy.

7). Parona e Perugia—Di alcuni trematodi ectoparassiti di pesci adriatici. *Op. cit.*, ser. 2, vol. IX, 1890. Estratto p. 3-5.

*T. uncinatum*, was described by Monticelli<sup>1)</sup>; and finally in 1891 three species were added to the genus, two (*T. irreptum* and *T. Lervinsenii*) by Monticelli<sup>2)</sup> and one (*T. histiophori*) by Jeffrey Bell<sup>3)</sup>.

The emended generic diagnosis of Diesing<sup>4)</sup> is as follows: "Corpus suborbiculare v. oblongum, planum v. depressum. Caput discretum, acetabulis duobus marginalibus v. juxtapositis subcircularibus. Os inter acetabula subterminale. Acetabulum corporis radiatum ventrale inferum, sessile, disciforme explanatum, intus septemradiatum, disco centrali minore. Androgyna; aperturæ genitales approximatae, feminea infra os, mascula in sinistro corporis latere, pene filiformi. Porus excretorius.....Tractus intestinalis bicurvis, coecus. Ovipara.—Piscium marinorum ectoparasita." Following closely Braun and St.-Remy I give the generic diagnosis as follows:

Body circular to elongated-oval, much flattened; with two circular or elliptical anterior suckers at the anterior end of the body on either side of the subterminal mouth, and a single circular sessile sucker at the posterior extremity. Posterior sucker provided with a marginal membrane, with its internal surface divided by means of a certain number of radial septa and the bars connecting them, into a central polygonal area and a certain number of peripheral areas; generally carrying hooks (mostly one pair). Uterus opening into the genital atrium or independently of it directly to the exterior. Genital opening or openings ventral, on the left side of the body near the anterior sucker. With a vagina opening ventrally on the left side of the body,

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1). Monticelli—*Tristomum uncinatum*, n. sp. Boll. d. Soc. d. Nat. in Napoli. An. III, fasc. II. 1889. pp. 117-119. With one plate.

2). Monticelli—Di alcuni organi di tatto nei Tristomidi: Contributo al. Stud. d. Trem. monog., parte I. Boll. d. Soc. d. Nat. in Napoli. Ser. I., ann. 5., vol. 5, 1891. p. 122, Notes III & IV.

3). Jeffrey Bell—Description of a New Species of *Tristomum* from *Histiophorus brevirostris*. Annals & Mag. of Nat. Hist., vol. VII, 6th. ser., 1891. pp. 534-535.

4). Diesing—Revision d. Myzhelminthen, p. 365.



more or less behind the common genital opening or the male and female openings.

*I. Tristomum sinuatum*, n. sp.

(Pls. XX, XXI, XXII.)

*Body* ovato-oval, about 8 mm. long by 7 mm. broad, anterior border concave, with a deep, acute notch at the posterior end, with numerous uniformly scattered, small papillae on the dorsal side, ventrally smooth; lateral margins sinuate and with a minute crown-shaped chitinous body<sup>1)</sup> at the top of each wave (Pl. XX, fig. 3). *Anterior suckers* elliptical, of moderate size, attached to the body at the apices of deep indentations that divide the anterior from the lateral margins of the body. *Posterior sucker* circular, small, only about twice as large as the anterior sucker, at the apex of the posterior notch, much in front of the posterior end of the body; central area forming a regular heptagon with one of its sides perpendicular to the long axis of the body, with an isosceles-trapezoidal peripheral area corresponding to each of its sides; the two equal sides of the hindmost peripheral area bifurcating towards their outer ends and thus giving rise to a small accessory, triangular area on each side. *Hooks* present in a single pair, stout, solid, slightly curved, and with free end curved like the claw of a cat (Pl. XX, fig. 2), 0.195 mm. long, situated at the ends of the posterior border of the central heptagon. *Mouth* small, at the plane of the beginning of the hindmost third of the anterior suckers. *Pharynx* simple, short, cylindrical. *Oesophagus* exceedingly short. *Intestinal trunks* continuous behind, describing some distance in front of the posterior sucker an arc with its convexity turned forwards; with numerous repeatedly bifur-

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1). In one specimen I have counted fifty-eight of these bodies on each side.

ating lateral branches on the outer side and a smaller number (about four or five) of less repeatedly dividing branches on the inner. The foremost inner branches of both sides form a pair, and proceed at first backwards and towards the median line and then again diverge, thus making the figure of two bows with their backs turned towards each other; the branches of the two sides being, however, often of unequal lengths. Common *genital opening* close behind the anterior sucker of the left side. *Penis* club-shaped, of moderate length. *Ovary* much lobed, in the median line, at the beginning of the middle third of the body. *Oviduct* arising from the ventral side of the anterior end of the ovary, proceeding forwards and towards the left dorsally to the yolk-duct, continued into the ootyp about midway between the hinder end of the penis and the front end of the vitelline reservoir. *Uterus* of moderate length, following the same general course as the oviduct, opening into the genital atrium at a short distance from the external opening of the latter. *Vitellarium* almost wholly confined to the lateral and posterior regions of the body, but also following the intestinal branches into the median region; with a large *yolk-duct* just inside the intestinal trunk on each side; this yolk-duct, by its union with a similar duct coming from the anterior part at the plane of the front end of the ovary, gives rise to the *paired yolk-duct*, which uniting with its fellow of the opposite side at the front end of the ovary on the left side of the median line, forms here a large *yolk-reservoir*. From this the *unpaired yolk-duct* proceeds dorsal, anteriad, and towards the right, and opens into the oviduct. *Vaginal opening* a short distance behind the common genital opening, a little farther from the median line; the much convoluted vaginal canal lies for the most part just outside the vas deferens, is swollen into a comparatively small *receptaculum seminis* near its external pore, and finally opens into the yolk-reservoir. *Testes* small, very numerous, confined to the median

region between the intestinal trunks, mostly behind the ovary, but extending also forwards on both sides about midway up the ovary. Numerous *vasa efferentia* uniting in the median line and forming a single *vas deferens*, which, with numerous convolutions, proceeds forwards, keeping itself close on the left side of the ovary, and reaching the front end of the latter here forms a long loop with its closed end directed forwards and towards the right; after this the *vas deferens* proceeds, still with complicated convolutions, for a short distance forwards, then bends towards the right; and entering the penis at its base, finally opens into its cavity on the top of a papilla, at a short distance from its apex; its calibre generally decreasing all along after the large loop at the front end of the ovary.

This species has a light flesh-red colour of its own, which does not wholly disappear in alcoholic specimens.

*Habitat*—Inner side of the gill-plates of *Histiophorus* sp. (Jap. Kajiki).

*Locality*—Misaki.

*Date*—August 1891.

2. *Tristomum ovale*, n. sp.

(Pl. XXIII; Pl. XXIV, figs. 1-5.)

*Body* oval, about 13 mm. long by 12 mm. broad or larger, sometimes approaching more nearly a circle, with numerous, uniformly scattered conspicuous papillae on the ventral surface, dorsally smooth. Anterior border convex, separated from the lateral borders by a deep, large notch on each side, at the apex of which is attached the anterior sucker of either side; posterior end with a large obtuse notch. Lateral margins entire, destitute of chitinous bodies. *Anterior suckers* of moderate size, nearly circular, with numerous papillae on their inner margins.

*Posterior sucker* circular, large, with a diameter equal to half the length of the body proper ; projecting beyond the body by about one-third of its diameter, with a marginal membrane ; central area a nine-sided polygon formed by bringing the shorter of the two parallel sides of an isosceles trapezoid on one side of a regular heptagon and by obliterating the boundary (*i. e.*, central heptagon open behind), and with the added trapezoid projecting backwards ; peripheral areas seven in number, the four anterior of equal size, with the form of an isosceles trapezoid, the next two on either side of a different form from the others, but similar to each other, with the form of an isosceles trapezoid with one of its corners cut off obliquely ; and the hindmost area which occupies the median line again with the form of an isosceles trapezoid, but much smaller than the others. *Hooks* in one pair, solid, flattened, with a form like that of the butcher's knife (Pl. XXIII, fig. 2), longitudinally furrowed, with a deep notch at the proximal end, large, being 0.91 mm., imbedded in the non-parallel sides of the isosceles-trapezoidal portion of the central area. *Mouth* at some distance from the front end of the body, between the anterior suckers, a little anterior to the plane of their hinder ends. *Pharynx* double, *i. e.*, divided by a deep constriction into an anterior, larger portion and a posterior, smaller portion, so that the whole has somewhat the form of the numeral 8. *Oesophagus* very short. *Intestinal trunks* continuous with each other posteriorly a little behind the anterior end of the posterior sucker, enclosing a rather small, rectangular area ; each with a small number (5) of lateral, repeatedly bifurcating branches on the outer side, and only about three shorter branches on the inner. *Penis* exceedingly large and long, cylindrical, often projecting beyond the opening of the genital atrium. *Ovary* sub-globular, much lobed, in the median line, at the hinder end of the anterior

half of the body proper. *Oviduct* arising from the ventral side of the ovary; thence proceeding forwards and towards the left it is continued into the ootyp at about the plane of the hinder end of the penis. *Uterus* of moderate length, running parallel to the penis, and opening to the exterior just behind the opening of the genital atrium. *Vitellarium* occupying nearly all those portions of the body left vacant by the other internal organs, extending from the anterior nearly to the posterior end of the body, and also occupying the whole dorsal side of the median region enclosed by the intestinal trunks. *Paired yolk-ducts* formed by the union of two large ducts coming from the anterior and posterior regions of the vitellarium on each side of the body, or by the union of a larger number of smaller ducts; proceeding at right angles to the long axis of the body, and forming by their union a large yolk-reservoir at the front end of the ovary just on the left side of the median line. *Unpaired yolk-duct* short, proceeding dorsally from the yolk-reservoir and opening into the oviduct. *Vaginal opening* a little behind that of the uterus, nearer the median line; *vaginal canal* proceeding backwards and inwards at first with a slight winding or two, but reaching the plane of the yolk-reservoir it makes some complicated convolutions and after being enlarged into a *seminal receptacle*, finally opens into the yolk-reservoir. *Testes* rather small, very numerous, of an irregular shape and more or less lobed, not confined to the median region of the body but extending on both sides a little less than two-thirds the distance between the lateral margins of the body and the intestinal trunks, and in the latter regions reaching from the hinder end of the anterior suckers to the front end of the posterior sucker; the whole area occupied by the testes thus assuming somewhat the form of a cross-section of a biconcave lens. *Vas deferens* formed by the union of a certain number of vasa efferentia at the posterior, left corner of the ovary, thence proceeding forwards

on the left side of the ovary, and reaching the plane of the anterior end of the latter, it bends towards the right and forms a large loop with secondary windings lying horizontally just in front of the ovary, with its closed end directed towards the right; after this the vas deferens makes numerous, complicated convolutions, and proceeds forwards and towards the left, keeping itself just inside the vaginal canal; a little in front of the ootyp it bends towards the right and enters the penis at some distance from its base, and finally opens into its cavity on the top of a small papilla at some distance from its apex; diminishing in calibre generally all the way after forming the large loop just in front of the ovary.

*Habitat*—Mouth-cavity of *Histiophorus orientalis* (Jap. Bashō-kajiki), *Histiophorus* sp. (Jap. Kajiki), and another undetermined species perhaps of the genus *Cybbium* (Jap. Oki-ma-zawara).

*Locality*—Misaki.

*Date*—August 1891 and '92.

This species may possibly prove identical with *T. histiophori* of Jeffrey Bell, specimens of which had been collected in Madras by F. Day from *Histiophorus brevirostris*; but from the meagreness of the description I am not able to determine whether it is really so or not. For the sake of comparison I here subjoin the whole description<sup>1)</sup> and the measurements of the worm recorded: "With a close resemblance to *T. coccineum*, it is distinguished by the absence of parallel rows of chitinous corpuscles and by the fact that the posterior sucker projects by about one-third of its diameter beyond the margin of the body." Measurements of three specimens are stated to have been respectively 15 mm. × 12 mm., 14 mm. × 11.5 mm., and 10.5 mm. × 10 mm.

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1). Jeffrey Bell—Description of a New Species of Tristomum from *Histiophorus brevirostris*. *Annals and Magazine of Nat. Hist.*, vol. VII, 6th ser. 1891. pp. 531-535.

3. *Tristomum rotundum*, n. sp.

(Pl. XXIV, figs. 6-9.)

*Body* oval in the state of perfect rest, with the antero-posterior axis shorter, about 11.5 mm. by 13 mm., but sometimes a little longer antero-posteriorly; smooth both dorsally and ventrally; with the anterior border concave, and separated from either lateral margin by a deep, not very wide notch; with only a shallow concavity on the posterior border. Lateral margins entire, with numerous transverse rows of chitinous bodies somewhat similar in form to those of *T. mole*<sup>1)</sup>; each row consisting of four or five bodies in the middle part but diminishing in number towards both ends, beginning just a little behind the anterior suckers and entirely absent for a certain stretch on the concavity at the posterior end of the body, on both sides of which each row contains only a single chitinous body. *Anterior suckers* elliptical, of moderate size, attached to the body at the apices of the notches that divide the lateral from the anterior border of the body. *Posterior sucker* circular, with its hinder end scarcely reaching the posterior border of the body, of moderate size, with a diameter equal to about one-third the length of the body proper; with an elevated, central, regularly heptagonal area and seven peripheral areas of the form of an isosceles trapezoid; the latter all of equal size and the hindmost one occupying the median line of the body. *Hooks* in one pair, solid, imbedded at the ends of the posterior side of the central heptagon, thickened and pointed at both ends, but with the free end sharper, of the form represented in fig. 8, Pl. XXIV, 9.16 mm. in length. *Mouth* small, between the anterior suckers, at the plane of the beginning of the posterior third of

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1). Parona e Perugia—Res lignusticae, VIII. Di alcuni trematodi ectopar. d. pesci marini: Nota preventiva. *Op. cit.*, ser. 2, vol. VII, 1888. p. 741.

their lengths. *Pharynx* simple but slightly constricted in the middle, short, cylindrical. *Oesophagus* very short. *Intestinal trunks* continuous posteriorly a little in front of the posterior sucker, enclosing a kidney-shaped area; the posterior commissural limb very slightly curved, with its convexity directed forwards; each intestinal trunk with numerous, repeatedly bifurcating branches on the outer side, but sending only a few branches on the inner, two of which are longer than the others and send out secondary branches. The foremost of these approaches its fellow of the opposite side in the median line of the body and forms with it the figure of two bows with their backs turned against each other, as in *T. sinuatum*. *Penis* tolerably long, club-shaped. *Ovary* in the hinder part of the anterior half of the body proper, roundish, longer transversely than antero-posteriorly, deeply lobed. *Oviduct* arising at the front end of the ovary in the median line, and thence proceeding at first towards the left and then more forwards, it is continued into the ootyp. *Uterus* tolerably long, opening to the exterior just behind the opening of the genital atrium, on the same plane with the hinder end of the anterior sucker. *Vitellarium* mostly confined to the lateral regions of the body, but also extending into the anterior, median lobe of the body, and wholly absent from the median region except around the intestinal branches. *Paired yolk-ducts* formed by the union of two large yolk-ducts as in the other species; uniting with each other and forming a *yolk-reservoir* at the front end of the ovary a little on the left side of the median line. *Unpaired yolk-duct* very short, connecting the yolk-reservoir with the oviduct. *Vaginal opening* some distance behind the uterine opening and more removed from the median line; *vaginal canal* proceeding backwards and towards the median line with numerous close convolutions, forming a capacious, elongated flask-shaped *receptaculum seminis*



about midway on its whole course, and finally opening into the yolk-reservoir. *Testes* small, numerous, confined to the median region enclosed by the intestinal trunks, mostly behind the ovary. *Vas deferens* taking the usual course up to the anterior end of the ovary; the loop which it forms at this level is placed perfectly transversely to the length of the body, with the closed end directed as usual towards the right; after this the vas deferens proceeds forwards, making numerous convolutions on the way, and reaching the front end of the ootype turns backwards, and enters the penis at a short distance from its base, and describing some convolutions within it finally opens into its cavity about midway its whole length; the calibre of the vas deferens being very small in the latter part of its course.

Like *T. sinuatum* this species has a light flesh-red colour of its own.

*Habitat*—Gill of *Niphius gladius* (Jap. Mekajiki).

*Locality*—Misaki.

*Date*—August 1891.

This species is evidently very closely related to *T. coccineum*, with which I have at first suspected it to be identical. And even now I find myself unable to give up this suspicion, although there are some small but positive differences between the two species if Taschenberg's figures<sup>1)</sup> are perfectly accurate. In the first place the form of the hooks is different, being in *T. coccineum* simply obliquely hollowed out at the two ends; and in the second place the transverse rows of minute chitinous bodies on the lateral margins of the body are in *T. rotundum* wholly absent on the concavity at the posterior end of the body, whereas in *T. coccineum* the rows of both sides are, accord-

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1). Taschenberg—Beiträge etc.

ing to Taschenberg, wholly continuous with each other along the posterior border of the body.

4. *Tristomum foliaceum*, n. sp.

(Pl. XXIV, figs. 10-12; Pl. XXV, fig. 9.)

*Body* elongated, slightly ovate, about 6 mm. by 3 mm.; with the anterior border brace-shaped (—); lateral margins entire, destitute of any chitinous corpuscle, and divided from the median, anterior lobe of the body only by a slight constriction, where the anterior suckers are attached; with a not very deep notch at the posterior end. *Anterior suckers* circular, of moderate size in comparison to the body. *Posterior sucker* slightly elliptical, with the major axis directed antero-posteriorly, projecting beyond the body by about one-third of its length; provided with a marginal membrane; with a diameter equal to the breadth of the body just behind the anterior suckers; its internal surface divided into areas just as in *T. orale*. *Hooks* in one pair, in position as they are in *T. orale*, hollow, spinous, with a deep notch at the proximal end, of the form represented in fig. 11, Pl. XXIV, about 0.175 mm. long on the average. In the specimen examined by me the hooks were of unequal lengths on the two sides, that of one side being 0.164 mm. and that of the other 0.186 mm., thus giving the average above recorded. *Mouth* of moderate size, at the plane of the hinder end of the anterior suckers. *Pharynx* divided by a constriction into two unequal portions as in *T. orale*. *Oesophagus* very short. *Intestinal trunks* continuous with each other behind, a little in front of the posterior sucker, with numerous dendritic branches on the outer side, and with a few shorter branches on the inner; enclosing a not very extensive area in the middle portion of the body similar in form to that of the latter. *Common genital opening* a little on the left side of

the pharynx, at about the plane of the middle of the whole length of the latter. *Penis* short and thick. *Ovary* at the hinder end of the anterior third of the body proper, ovoid, being longer from right to left, not lobed. *Oviduct* arising at the front end of the ovary in the median line, thence proceeding forwards with a slight winding or two, and continued into the ootyp. *Uterus* not very long, opening into the genital atrium near its bottom. *Vitellarium* mainly confined to the lateral regions and the anterior lobe of the body, and only accompanying the intestinal branches into the median region. *Paired yolk-ducts*, *yolk-reservoir*, and *unpaired yolk-duct* as in the preceding species. *Testes* small, globular, numerous, confined to the median region between the intestinal trunks. *Vaginal opening* a little behind the common genital opening; *vaginal canal* proceeding as usual backwards and towards the median line, and after forming a capacious, globular *receptaculum seminis*, opening finally into the yolk-reservoir.

*Habitat*—Gill of an undetermined species of fish the Japanese name of which is Hazara.

*Locality*—Misaki.

*Date*—August 1891.

5. *Tristomum Nozawae*,<sup>1)</sup> n. sp.

(Pl. XXV, figs. 1-3.)

*Body* elongated-ovate, about 12 mm. long by 7 mm. broad, with the truncate anterior border perfectly straight, with the anterior lobe of the body separated from the lateral borders only by a shallow constriction; lateral margin entire, destitute of any chitinous corpusele; with a large notch at the posterior end of the body

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1). Dedicated to Shunjiro Nozawa, *Nōgakushi*, Naturalist to the Fisheries Bureau of the Hokkaidō Chō, to whom as well as to Kazutaka Itō Esq., the then Director of the Fisheries Bureau, are due my best thanks for giving me numerous facilities for collection during my stay in Hakodadō.

proper. *Anterior suckers* of moderate size, nearly circular. *Posterior sucker* slightly elliptical, with its major axis coinciding with the median line of the body ; with a diameter equal to the breadth of the body at the plane of the mouth ; with its internal surface divided into areas like those of *T. orale* and *T. foliaceum*. *Hooks* in one pair, in a position similar to that in the two species just mentioned, long, slender, slightly curved, with a narrow cavity in the interior, 0.18 mm. long. *Mouth* small, a little in front of the plane of the hinder end of the anterior sucker. *Pharynx* elongated, with a constriction at the middle of its length as in *T. orale* and *T. foliaceum*. *Oesophagus* very short. *Intestinal trunks* continuous behind just in front of the posterior sucker, enclosing an area of a similar form to that of the body, but with the posterior commissural limb straight ; with numerous, dendritic branches on the outer side and with a few short, simple branches on the inner. *Common genital opening* a little behind the anterior sucker of the left side. *Penis* short and small, club-shaped. *Ovary* in the hinder part of the anterior half of the body proper, irregularly globular, not lobed. *Oviduct* arising from the front end of the ovary, thence proceeding forwards with a slight winding or two, and soon continued into the ootyp. *Uterus* of moderate length, opening into the genital atrium at a short distance from its external pore. *Vitellarium* present not only in the lateral regions and the anterior lobe of the body but also on the whole dorsal side of the posterior two-thirds of the median region enclosed by the intestinal trunks; but in the latter region the lobes are more sparsely distributed than in the former. *Paired yolk-duets* formed as usual by the union of large duets coming from the anterior and the posterior part. *Yolk-reservoir* and *unpaired yolk-duct* as usual. *Vaginal opening* a little behind the common genital opening but nearer the median line ; *vaginal canal* proceeding, as usual, backwards and inwards with numerous convolutions, forming

a capacious ovoidal *receptaculum seminis* at about two-thirds of its whole course, and finally opening into the yolk-reservoir. *Testes* numerous, globular, present not only in the median region posterior to the ovary, but extending on both sides a little way into the lateral regions of the body. *Vas deferens* formed as usual, proceeding at first forwards on the left side of the ovary; forming, also as usual, a large loop at the front end of the ovary, and after describing numerous, complicated convolutions it enters the penis, inside which it expands and forms a sort of *vesicula seminalis*, and finally opens into the cavity of the penis at a short distance from its apex.

The body of this species is so transparent that even in alcoholic specimens the internal organs, even the smallest vasa efferentia, can be seen through, and their relations ascertained without staining and mounting.

*Habitat*—Fin of *Thynnus sibi* (Jap. Shibi).

*Locality*—Osatsube (Hokkaidō); collected by Mr. Nozawa in whose honour it is named.

*Date*—Not recorded.

6. *Tristomum biparasiticum*, n. sp.

(Pl. XXV, figs. 4-8.)

*Body* elongated-oval, about 6 mm. long by 3 mm. broad, with a sudden diminution of breadth in the anterior part a little behind the anterior suckers; with the anterior border slightly convex; with a notch at the posterior end of the body; lateral margins entire, with a series (of about sixty-two) of chitinous corpuseles like those of *Trist. sinuatum*, one of which is represented in fig. 5, Pl. XXV; the series beginning a little behind the anterior suckers at the point where the body undergoes a sudden increase of breadth, and terminating a little before reaching the posterior sucker. *Anterior suckers* nearly

circular. *Posterior sucker* slightly elliptical, with its longer axis directed antero-posteriorly and with a diameter equal to about one-fifth the length of the body proper; with a marginal membrane and with its internal surface divided into areas like those of *T. Nozawae*, *T. ovale*, and *T. foliaceum*. *Hooks* in one pair, in the position of those in the species just mentioned, solid, straight, bifurcating at the proximal end, with a pointed, free end and with a barb-like process near it (fig. 6, Pl. XXV); 0.111 mm. long. (In the specimen on which I made the measurement, the hooks of the two sides were of unequal length, that of one side being 0.122 mm. and that of the other 0.100 mm., thus giving the average above recorded.) *Mouth* small, at the same plane with the hinder end of the anterior suckers. *Pharynx* divided by a constriction into two unequal parts. *Oesophagus* very short. *Intestinal trunks* continuous with each other some distance in front of the posterior sucker, enclosing an elongated, oval area a little less than half as long as the whole body; sending out numerous (about ten), dendritic branches on the outer side and about as many shorter branches on the inner. *Common genital opening* a little behind the anterior sucker of the left side, about midway between the lateral margin of the body and the pharynx. *Penis* of moderate length, club-shaped. *Ovary* at the hinder end of the anterior third of the body, of a similar form to that of *T. foliaceum*. *Oviduct* arising at the front end of the ovary in the median line, and thence proceeding forwards and towards the left it is continued into the ootyp at the level of the base of the penis. *Uterus* short, opening into the genital atrium about midway between its external pore and the base of the penis. *Vitellarium* confined to the lateral regions and the anterior lobe of the body, only accompanying the intestinal branches into the median region. *Paired yolk-ducts*, *yolk-reservoir*, and *unpaired yolk-duct* as in *T. foliaceum*. *Vaginal opening* about as much behind the common genital opening as

this is behind the anterior sucker, but a little nearer the median line; *vaginal canal* swollen at the beginning, then becoming very fine, and taking the usual course and describing some convolutions, opens at last into the yolk-reservoir after it has formed an elongated, oval, capacious *receptaculum seminis* just in front of the reservoir. *Testes* numerous, irregularly polygonal, confined to the median region between the intestinal trunks, mostly behind the ovary.

*Habitat*—Carapace of a copepod, probably of the genus *Parapetulus*, parasitic on the gill of *Thynnus albacora* (Jap. Sōda-gatsuwo).

*Locality*—Misaki.

*Date*—August 1891.

Tokyo, March 12, 1894.



### Analytical Key to the Species described.

Body symmetrical except in a few cases.

†<sup>1</sup> With a pair of spheroidal suckers within the mouth,  
and with numerous, small, flattened suckers on both  
sides of the caudal disc; body sometimes asym-  
metrical ... ..MICROCOTYLE. p. 185.

‡<sup>1</sup> Body symmetrical, about 3.2 mm. long; caudal  
disc distinctly separated from the body proper,  
about  $\frac{1}{3}$  the total length of the body; with about  
25 suckers on each side; genital atrium armed  
with slightly curved, conical spines... ..*M. caudata*. p. 186.

‡<sup>2</sup> Body symmetrical, slender, about 5.5 mm.  
long; caudal disc distinctly set off from the  
body proper, about  $\frac{1}{3}$  the total length of the  
body; suckers about 29 on each side; genital  
atrium armed with slightly curved, conical  
spines generally longer than those of  
*M. caudata* ... ..*M. sebastis*. p. 187.

‡<sup>3</sup> Body symmetrical, slender, about 4 mm. long;  
caudal disc distinctly set off from the body  
proper, a little longer than  $\frac{1}{3}$  the whole length  
of the body; suckers about 50 on each side;  
genital atrium armed with conical spines about  
0.005 mm. long... ..*M. elegans*. p. 188.

‡<sup>4</sup> Body slightly asymmetrical, elongated, thick,  
6-10mm. long; caudal disc not distinctly separat-  
ed from the body proper, somewhat longer  
than  $\frac{1}{3}$  the total length of the body; suckers  
about 42 on one side and 23 on the other;  
intestinal branches forming a complicated



network; genital atrium armed with straight spines consisting of a hemispherical, basal portion and a straight, spinous, distal portion...*M. reticulata*. p. 189.

<sup>35</sup> Body symmetrical, slender, about 3.3 mm. long; caudal disc not distinctly separated from the body proper, very short, isosceles-trapezoidal, with about 10 suckers on each side; genital atrium armed with 20 long, chitinous rods arranged in a circle ... ..*M. truncata*. p. 191.

<sup>36</sup> Body symmetrical, fusiform, about 2 mm. long; caudal disc not separated by a constriction from the body proper, nearly  $\frac{1}{2}$  the total length of the body, with about 30 or more suckers on each side; genital atrium armed with short, conical spines ... ..*M. fusiformis*. p. 192.

<sup>37</sup> Body symmetrical, anterior portion slender but the remaining portion broader, about 4.2 mm. long; caudal disc not separated from the body proper by a constriction, with about 30 suckers on each side; genital atrium with a cup-shaped organ, the internal surface of which is covered with straight, conical spines consisting of a hemispherical, basal and a spinous, distal portion ... ..*M. chiri*. p. 193.

<sup>38</sup> Body prominently asymmetrical, slender, about 4 mm. long; caudal disc slender and pointed at the end, making an angle with the body proper, with about 75 suckers on one side and 60 on the other; genital atrium with a bell-shaped organ, and armed with two sets of slender, chitinous rods, one of which is hook-shaped and short, and the other slightly curved and long ... ..*M. sciacaenae*. p. 194.

<sup>†2</sup> Body always symmetrical; with a pair of spheroidal suckers within the mouth, and with four pairs of

small, bean-shaped, sessile suckers arranged in straight lines on each side on the ventral surface of the hindmost portion of the body; penis consisting of three bulbs armed with long, hollow spines; with chitinous hooks at the posterior end of the body ...OCTOCOTYLE. p. 203.

<sup>21</sup> Body thick, about 4 mm. long; with a single pair of hooks at the posterior end of the body; penis spines in 5 pairs ... O. major. p. 203.

<sup>22</sup> Body thick, about 2 mm. long; with two pairs of hooks at the posterior end of the body, the inner pair being filiform; penis spines in 6 pairs ... O. minor. p. 205.

<sup>13</sup> Body always symmetrical; with a pair of spheroidal suckers within the mouth, and with four pairs of hemispherical suckers arranged in a semicircle or a horse-shoe shape at the posterior end of the body, mostly provided with pedicels; penis spherical and with a certain number of hooks; without any hook at the posterior end of the body... DICLIDOPHORA. p. 207.

<sup>21</sup> Body elongated,  $6\frac{1}{3}$ -8 mm. long, in form like that of the leaf of a rose with a narrow anterior portion; with the four pairs of hemispherical posterior suckers, arranged in a semicircle at the top of long pedicels; penis with 6 hooks ... D. smar. p. 207.

<sup>22</sup> Body elongated, not so broad as in the preceding, about 8 mm. long; posterior suckers hemispherical, with long pedicels and arranged in a semicircle; penis with 8 hooks ... D. elongata. p. 210.

<sup>23</sup> Body elongated-oval, about 5 mm. long; posterior suckers hemispherical, sub-sessile, arranged in a semicircle; penis with 6 hooks... D. sessilis. p. 212.

<sup>24</sup> Body long and slender, spatulate, 5-15 mm. long, with a long, slender posterior portion; posterior suckers sessile, semi-ellipsoidal,

arranged in a horse-shoe shape; penis with

10 hooks ... ..D. tetrodonis. p. 213.

†<sup>4</sup> Body always symmetrical; with a pair of exceedingly small spheroidal suckers within the mouth, and with four pairs of semi-ellipsoidal suckers at the posterior end of the body, the innermost pair of which is considerably smaller than the others; with two pairs of hooks between the innermost pair of posterior suckers... ..HEXACOTYLE. p. 217.

<sup>21</sup> Body acutely pointed in front, broad in the middle portion as well as at the posterior end, about 11 mm. long; with the outer pair of hooks at the posterior end solid, about 0.09 mm. long; vagina armed with chitinous teeth.H. acuta. p. 217.

<sup>22</sup> Body with a lateral swelling on each side close to the front end, with the anterior portion slender, broad in the middle part as well as at the posterior end, about 18 mm. long; with the outer pair of hooks hollow and about 0.125 mm.

long; vagina armed with chitinous teeth ...H. grossa. p. 220.

†<sup>5</sup> Body always symmetrical, elongated and slender; with an ellipsoidal sucker around the mouth-cavity; with three pairs of hemispherical suckers at the posterior end of the body, each with a semicircular chitinous rod with a claw at one end; with a sub-cylindrical appendage projecting from between the foremost pair of suckers. ... ..ONCHOCOTYLE. p. 223.

<sup>23</sup> Posterior suckers arranged in a horse-shoe shape; appendage bifid at the extremity, with a pair of small suckers at the bifid end, and a pair of hooks between them ... ..O. spinacis. p. 224.

†<sup>6</sup> Body always symmetrical, flat, heart-shaped; with a rudimentary sucker around the mouth; with a circular posterior sucker, the internal surface of which is divided into a subcentral and seven peri-

pheral areas ; with a pair of hooks in the sides of the hindmost peripheral area ... ..CALICOTYLE. p. 226.

\*<sup>1</sup> Body very flat, ovate, about 8 mm. by 5 mm.; posterior sucker sessile, with a diameter equal to about  $\frac{1}{3}$  the total length of the body ; with two pairs of sac-like sticky glands opening by means of long necks at the anterior end of the body ; tubular chitinous penis very long and twice bent on itself ; hooks about 0.56 mm.

long ... ..C. Mitsukurii. p. 227.

†<sup>7</sup> Body always symmetrical, without any anterior sucker, but with a large, circular posterior sucker, the internal surface of which is divided by eight radial spokes into as many equal secants ; two of the posterior radial spokes on either side of the median line each with a strong hook ; with two pairs of ocular spots in front of the pharynx ... ..MONOCOTYLE. p. 230.

\*<sup>1</sup> Body elongated, flattened, about 3 mm. long ; mouth sub-terminal, large ; sucker sub-basilar ; hooks strongly recurved at the end but straight in the remaining portion, and with a barb-like process near the recurved end ; about 0.12 mm.

long... ..M. Ijima. p. 230.

†<sup>8</sup> Body flat, oval, ovate, or circular ; with a pair of saucer-shaped anterior suckers on either side of the mouth, and a circular sucker at the posterior end of the body.

\*<sup>1</sup> Internal surface of the posterior sucker not divided into areas, and with three pairs of hooks ; anterior suckers connected together by a membrane ... ..EPIBELLA. p. 233.

§<sup>1</sup> Body elongated-oval, flat, about 4 mm.

long ; anterior suckers nearly circular ;

posterior sucker circular ... ..E. Ishikawae. p. 234.

§<sup>2</sup> Body squarish-oval, flat, about 2 mm.

long; anterior suckers elliptical; posterior sucker with a pair of notches on its anterior

and posterior borders ... ..E. ovata. p. 235.

\*<sup>2</sup> Internal surface of the posterior sucker divided

into a central and seven peripheral areas... ..TRISTOMUM. p. 238.

§<sup>1</sup> Body broadly ovate, about 8 mm. by 7

mm.; anterior border concave, lateral

margin finely sinuate, with about 58

chitinous corpuseles; posterior sucker

small, not reaching the posterior end of

the body proper, with the central area

regularly heptagonal and with a small

triangular accessory area on each side of

the hindmost peripheral area ... ..T. sinuatum. p. 239.

§<sup>2</sup> Body broadly oval, about 13 mm. by 12

mm. or larger; anterior border convex;

lateral margin entire, without any

chitinous corpusele; posterior sucker

large, with a diameter equal to about  $\frac{1}{2}$

the length of the body proper and pro-

jecting beyond it by one-third of its

diameter, with the central area 9-sided...T. ovale. p. 241.

§<sup>3</sup> Body oval, about 11.5 mm. by 13 mm.,

with the breadth greater than the length;

anterior border concave; lateral margin

entire, with numerous transverse series

of chitinous corpuseles, each series con-

sisting at most of five corpuseles; posterior

sucker small, barely reaching the posterior

end of the body proper; with the central

area regularly heptagonal and raised a

little above the peripheral areas ... ..T. rotundum. p. 245.

§<sup>4</sup> Body elongated and slightly ovate, about

6 mm. by 3 mm.; anterior border

~shaped; lateral margin entire and

destitute of chitinous corpuscles; posterior sucker tolerably large, slightly elliptical, with the central area 9-sided, projecting beyond the body proper by  $\frac{1}{2}$  of its length. *T. foliaceum*. p. 248.

§<sup>5</sup> Body elongated-ovate, about 12 mm. by 7 mm.; anterior border truncate; lateral margin entire, without any chitinous corpuscle; posterior sucker slightly elliptical, tolerably large, with the central area 9-sided ... .. *T. Nozawae*. p. 249.

§<sup>6</sup> Body elongated-oval, about 6 mm. by 3 mm.; anterior border slightly convex; lateral margin entire and with a series of about 62 chitinous corpuscles; posterior sucker slightly elliptical, of moderate size, with the central area 9-sided ... .. *T. biparasiticum*. p. 251.

Body always asymmetrical.

†<sup>9</sup> With a pair of spheroidal or egg-shaped suckers within the mouth and with an unequal number of generally small, flattened suckers on either side of the posterior part of the body; destitute of any hook at the posterior end of the body... .. *AXINE*. p. 196.

\*<sup>1</sup> Body with the form somewhat like that of the blade of the Turkish sword, flat, about 10 mm. long, with one side of the caudal disc making an obtuse angle with the corresponding side of the body proper; with about 30 suckers on one side and 9 on the other ... .. *A. heterocerca*. p. 197.

\*<sup>2</sup> Body curved towards one side, elongated, flat, about 5 mm. long; with one side of the caudal disc making an acute angle with the corresponding side of the body proper; caudal disc with about 25 suckers on one side and only one (or perhaps two or three?) on the other ... .. *A. aberrans*. p. 198.

\*<sup>3</sup> Body triangular, flat, short and broad, about

1.5 mm. long; with one side of the caudal disc making with the corresponding side of the body a less acute angle than in *A aberrans*; caudal disc with about 36 suckers on one side and only 6 on the other; genital atrium with a cup-shaped organ, the internal surface of which is covered with straight conical spines...*A. triangularis*. p. 200.

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[illegible]





# PLATE I.

## Plate I.

Figs. 1, 2, and 4 have been drawn from specimens killed under the pressure of a cover-slip and the body is consequently represented a little broader than it really is.

Nervous system yellow. Muscles of the posterior suckers red.

Fig. 1. *MICROCOTYLE CAUDATA*, viewed from the dorsal side.

" 2. *MICROCOTYLE SEBASTIS*, viewed from the dorsal side.

" 3. THE SAME in profile; free-hand, from a specimen killed free with hot sublimate.

" 4. *MICROCOTYLE ELEGANS*, viewed from the dorsal side.

" 5. *MICROCOTYLE RETICULATA*, viewed from the dorsal side.

*M. crinitata*

1

ant. sub. phan

ant. sub. phan

ant. sub. phan

ant. sub. phan

ant. sub. phan

ant. sub. phan

ant. sub. phan

ant. sub. phan

ant. sub. phan

ant. sub. phan

*M. subulata*

2

ant. sub. phan

ant. sub. phan

ant. sub. phan

ant. sub. phan

ant. sub. phan

ant. sub. phan

ant. sub. phan

ant. sub. phan

ant. sub. phan

*M. elegans*

3

ant. sub. phan

ant. sub. phan

ant. sub. phan

ant. sub. phan

ant. sub. phan

ant. sub. phan

ant. sub. phan

ant. sub. phan

ant. sub. phan

*M. reticulata*

5

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ant. sub. phan

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ant. sub. phan

ant. sub. phan

ant. sub. phan

ant. sub. phan

ant. sub. phan

ant. sub. phan





# PLATE II.

## Plate II.

- Fig. 1. *MICROCOTYLE TRUNCATA*, viewed from the dorsal side. From a specimen killed under the pressure of a cover-slip.
- " 2. *THE SAME*. Atrial spines. *a* the whole group viewed in a dorso-ventral direction; *b*, a single spine more strongly magnified; *c*, a single spine in cross-section. *b* & *c*, drawn free-hand.
- " 3. *MICROCOTYLE FUSIFORMIS*, viewed from the dorsal side. From a specimen killed under the pressure of a cover-slip.
- " 4. *MICROCOTYLE CURT*, viewed from the dorsal side. From a specimen killed under the pressure of a cover-slip.
- " 5. *THE SAME*, in a dorsal surface view. From a specimen killed free with hot sublimate; to show the natural form of the body.
- " 6. *MICROCOTYLE SCIAENAE*, viewed from the dorsal side. From a specimen killed free with hot sublimate.
- " 6a. *THE SAME*. Caudal disc viewed from the ventral side; to show the suckers.
- " 7. *MICROCOTYLE CAUDATA*. One of the posterior suckers in section.  $\times 305$  diam. *a*, chitinous rod of the anterior wall; *a'*, its continuation in the posterior wall; *b*, chitinous rod of the posterior wall; *c*, the median piece.





# PLATE III.

## Plate III.

### MICROCOTYLE SEBASTIS.

Fig. 1. Chitinous framework of the posterior sucker.  $\times 204$  diam.

### MICROCOTYLE RETICULATA.

Fig. 2. Semi-diagrammatic representation of the intestine.

„ 3. A small ventral portion of a cross-section of the body near its anterior end; to show the sticky glands. *a*, foremost end of the mouth-cavity.  $\times 305$  diam.

„ 4. A small ventral portion of a cross-section of the lateral part of the body.  $\times 305$  diam.

### MICROCOTYLE CHIRI.

Fig. 5. A small ventral portion of a median sagittal section of the body some distance in front of the ovary.  $\times 305$  diam.

### MICROCOTYLE TRUNCATA.

Fig. 6. A small portion of the mesenchyma lying just inwards to the intestinal trunk.  $\times 305$  diam.

### MICROCOTYLE CAUDATA.

Fig. 7. A small portion of the cross-section of the body through the front end of the anterior sucker; to show the sticky glands.  $\times 460$  diam.

„ 8. Anterior end of the body; to show the muscular fibres attached to the suckers.

„ 9. A small portion of the mesenchyma lying just inwards to the intestinal trunk.  $\times 305$  diam.

„ 10. Median portion of the cross-section of the body a little in front of its middle.  $\times 305$  diam.

---







# PLATE IV.

## Plate IV.

- Fig. 1. *MICROCOTYLE SEBASTIS*. Median sagittal section of the pharynx.  $\times 305$  diam.
- „ 2. *MICROCOTYLE RETICULATA*. Median portion of a cross-section of the body through about the middle of the pharynx.  $\times 204$  diam.
- „ 3. *THE SAME*. Horizontal (optic) section of the pharynx, showing the muscles; from a small individual.  $\times 305$  diam.
- „ 4. *MICROCOTYLE SEBASTIS*. Longitudinal section of the ootyp, showing the shell-glands.  $\times 305$  diam.
- „ 5. *THE SAME*. One-half of the cross-section of the body just through the anterior end of the brain; to show the nerve cells (*a*).  $\times 305$  diam.
- „ 6. *MICROCOTYLE FUSIFORMIS*. A cross-section of the body at the level of the origin of the posterior nerves.  $\times 305$  diam.
- „ 7. *MICROCOTYLE CAUDATA*. Lateral portion of a cross-section of the body.  $\times 305$  diam.
- „ 8. *THE SAME*. Median portion of a cross-section of the body through the region of the ovary. The yolk-duct was filled with yolk-cells, but these are not drawn in the figure.  $\times 305$  diam.
- „ 9. *THE SAME*. A portion of the section of the ovary near the oviduct end.  $\times 305$  diam.
-

1.

2.

9.



3.

4.



7.



8.





# PLATE V.

## Plate V.

Fig. 1—4 represent median sagittal sections.

- Fig. 1. *MICROCOTYLE FUSIFORMIS*.  $\times 305$  diam.  
„ 2. *MICROCOTYLE ELEGANS*.  $\times 305$  diam.  
„ 3. *MICROCOTYLE CAUDATA*.  $\times 305$  diam.  
„ 4. *MICROCOTYLE CHIRI*.  $\times 204$  diam.  
„ 5. *MICROCOTYLE RETICULATA*. Median portion of the cross-section of the body through the vaginal opening.  $\times 204$  diam.  
„ 6. *THE SAME*. Median portion of a cross-section of the body through the terminal portion of the vas deferens (6th section from the common genital opening, each=0.01 mm.).  $\times 204$  diam.  
„ 7. *MICROCOTYLE TRUNCATA*. A small portion of a horizontal section of the testes.  $\times 305$  diam.
-







PLATE VI.

## Plate VI.

- Fig. 1. *MICROCOTYLE SEBASTIS*. Median sagittal section through the region of the genital atrium.  $\times 305$  diam.
- „ 2. *MICROCOTYLE SCIAENAE*. Median sagittal section through the region of the genital atrium.  $\times 305$  diam.
- „ 3. *MICROCOTYLE CAUDATA*. Successive stages of spermatogenesis.  $\times 305$  diam. For detailed description see p. 86 of the text.
- „ 4. *DIPLOZOON NIPPONICUM*. Successive stages of spermatogenesis.  $\times 427$  diam. In *a* and *b* only the nucleus is represented; and in *c* and *d* the tail is cut short. For detailed description see p. 88 of the text.
-

1.

2.

a

b

c

d

W. Schuster

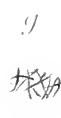
W. Schuster

3.

a

b

c



d

e

f

a

b

c

d

e

f

g

h



# PLATE VII.

## Plate VII.

### AXINE HETEROCERCA.

- Fig. 1. The whole worm viewed from the dorsal side; from a specimen killed under a slight pressure. *a*, dorsal opening of unknown nature (*cf.* fig. 4, Pl. VIII); \*, point of junction of the yolk-duct and the vaginal canal.
- „ 2. *I*, Chitinous framework of the posterior sucker.  $\times 73$  diam. *II*, terminal portion of the posterior arm of the median u-shaped piece. Free-hand.
- „ 3. Ovarian ova near the oviduct end.  $\times 305$  diam.
- „ 4. Section of the posterior sucker parallel to the median piece of the chitinous framework.  $\times 204$  diam.

### AXINE ABERRANS.

- Fig. 5. The whole worm viewed from the dorsal side.
- „ 6. *a*, chitinous armature of the terminal portion of the vas deferens.  $\times 305$  diam. *b*, the same of the vagina.  $\times 305$  diam.

### AXINE TRIANGULARIS.

- Fig. 7. The whole worm viewed from the ventral side.
- „ 8. *a*, cup-shaped organ of the genital atrium.  $\times 204$  diam. *b*, spine of the same.  $\times 460$  diam.
-

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oesoph.  
br.

cr.op.  
gen.op.

yk.uct.

vag.

ut.

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ut.

yk.duct.

int.

ov.

can.ge.int.

tes.

pos.suck.

pos.suck.

2.

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c

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stick.gl.

pen.

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sem.

a.

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tes.

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v.dcf

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oot.





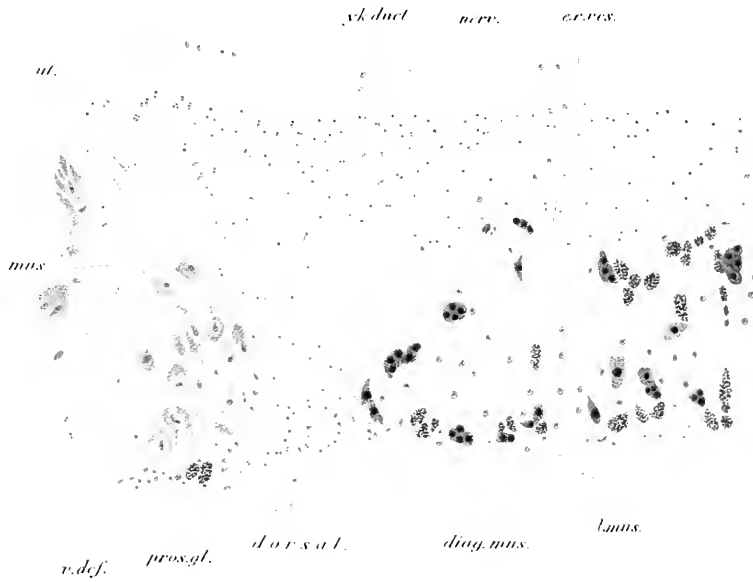
# PLATE VIII.

## Plate VIII.

### AXINE HETEROCERCA.

- Fig. 1. A portion of the cross-section of the body some distance behind the common genital opening.  $\times 204$  diam.
- „ 2. A small portion of the cross-section of the body through the anterior part of the brain.  $\times 204$  diam. *a*, nerve cells.
- „ 3. Median sagittal section of the body through the region of the common genital opening.  $\times 204$  diam.
- „ 4. Median sagittal section through the vagina.  $\times 204$  diam. *x*, an opening of unknown nature.
- „ 5. Ovary and the genital ducts adjoining it.  $\times 50$  diam.
-

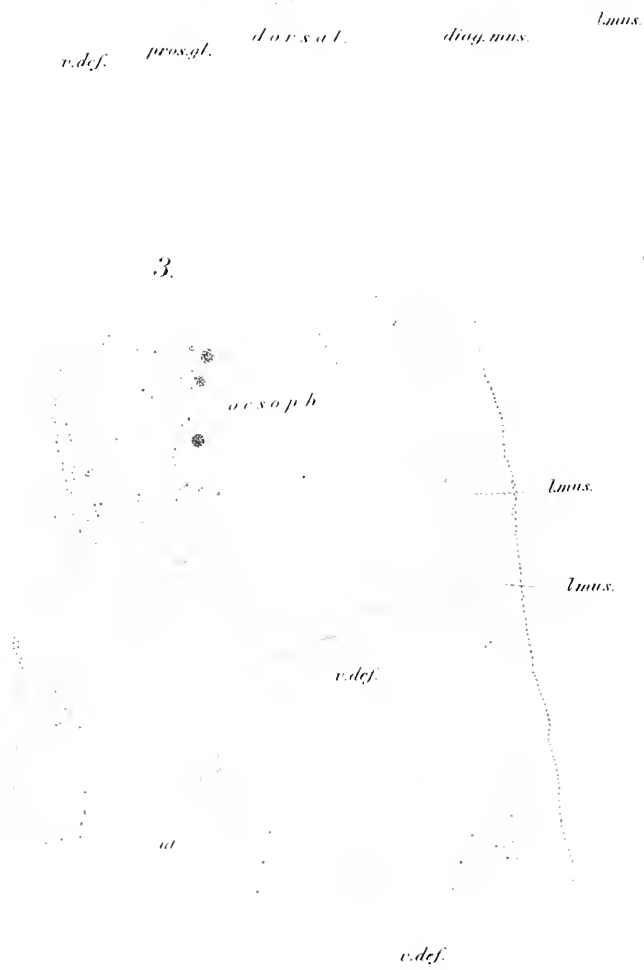
1.



2.



3.



b. anterior





# PLATE IX.

## Plate IX.

### OCTOCOTYLE MAJOR.

- Fig. 1. The whole worm viewed from the ventral side. From a specimen killed under the pressure of a cover-slip, and therefore much broader than it really is.
- „ 2. Hooks at the posterior end of the body, with muscular fibres attached.  $\times 204$  diam.
- „ 3. Chitinous framework of the posterior sucker viewed from one side.  $\times 305$  diam. The piece *b* is paired.
- „ 4. One of the posterior suckers viewed entire in profile.  $\times 305$  diam.
- „ 5. Penis viewed in its natural position from the ventral side.  $\times 305$  diam. For clearness' sake the spines are drawn fewer than they really are.
- „ 6. Ovarian ova near the oviduct end.  $\times 305$  diam.

### OCTOCOTYLE MINOR.

- Fig. 7. The whole worm viewed from the ventral side. From a specimen killed free with hot sublimate. The nervous system is shaded with parallel lines.
- „ 8. Anterior end of the body.  $\times 305$  diam. To show the attachment of muscular fibres to the anterior suckers.
- „ 9. Hooks at the posterior end of the body. *a*, outer pair;  $\times 305$  diam. *b*, inner pair;  $\times 427$  diam.
- „ 10. Chitinous framework of the posterior sucker viewed from one side.  $\times 305$  diam. The piece *b* is paired.
- „ 11. Female genital ducts viewed from the ventral side. Free-hand.
- „ 12. Median sagittal section through the region of the genital atrium.  $\times 305$  diam.
- „ 13. Penis viewed in its natural position from the ventral side.  $\times 305$  diam. The spines are represented one less than they really are.
-

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# PLATE X.

## Plate X.

### DICLIDOPHORA TETRODONIS.

- Fig. 1. The whole worm viewed from the ventral side. The uterus is greatly distended by the numerous eggs which it contains.
- „ 2. Surface view of the whole worm, from the ventral side.  $\times 5$  diam.
- „ 3. Anterior part of the body in profile.
- „ 4. Cross-section through the slender stalk-like portion of the body.  $\times 73$  diam.

### DICLIDOPHORA SESSILIS.

- Fig. 5. The whole worm viewed from the ventral side. Nervous system, chitinous framework of the suckers, and egg-shells yellow; excretory system indigo-blue; muscle of the posterior suckers red.
- „ 6. Anterior end of the body; to show the muscular fibres attached to the anterior suckers.  $\times 73$  diam.
- „ 7. *a*, hook of the penis a little in profile. *b*, basal portion of the same viewed from the front. Both  $\times 305$  diam.
- „ 8. Ovarian ova near the oviduct end.  $\times 305$  diam.

### DICLIDOPHORA ELONGATA.

- Fig. 9. The whole worm viewed from the ventral side. Nervous system yellow.
- „ 10. *a*, hook of the penis a little in profile. *b*, basal portion of the same viewed from the front. Both  $\times 305$  diam.
-

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int.

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ykduct

ov. ovd

can.ge.int.  
tes.

int.

3.

stick gl

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ex.op.

pen.

ut.

tes.

ykduct rec.sem

ov. can.ge.int.  
oot.

rec.sem.

stick gl.

9.

pen

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rit.

int

tes.

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a. b.

8.

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4. max.

2.

int.

dorsal

diag.mus.





PLATE XI.

## Plate XI.

### DICLIDOPHORA SESSILIS.

- Fig. 1. Cross-section of the body through the posterior part of the pharynx; to show a pair of gigantic ganglionic cells (*nerve. c.*).  $\times 204$  diam.
- „ 2. A portion of a cross-section of the body two sections (each = 0.01 mm.) behind the one represented in fig. 1; to show the ganglionic cells (*nerve. c.*) at the root of the posterior nerves.  $\times 204$  diam.
- „ 3. A small ventral portion of the right side of a cross-section of the body.  $\times 305$  diam.
- „ 4. An almost median sagittal section of the body through the region of the common genital opening.  $\times 204$  diam.
- „ 5. Median portion of a cross-section of the body through the *receptaculum seminis* at the level where it communicates with the oviduct.  $\times 204$  diam.
- „ 6. Diagonal muscular fibres, together with a few longitudinal fibres; drawn from a specimen *in toto*.  $\times 305$  diam.
- „ 7. Mesenchyma cells adjoining the oviduct end of the ovary.  $\times 305$  diam. Drawn from a specimen *in toto*.

### DICLIDOPHORA ELONGATA.

- Fig. 8. Three lobes of the vitellarium.  $\times 305$  diam.
-







# PLATE XII.

## Plate XII.

### DICLIDOPHORA ELONGATA.

- Fig. 1. Chitinous frame-work of the posterior sucker in surface view.  $\times$  about 73 diam. The semicircular series of chitinous, rod-shaped pieces are represented only in one quadrant.
- „ 2. One of the semicircular series of chitinous, rod-shaped pieces represented in the preceding figure.  $\times$  204 diam.

### DICLIDOPHORA SESSILIS.

- Fig. 3. Optic cross-section of the prismatic fibres of the posterior sucker;  $\times$  305 diam.
- „ 4. Section of a posterior sucker parallel to the length of its pedicel.  $\times$  204 diam.

### HEXACOTYLE ACUTA.

- Fig. 5. Median part of a cross-section of the body, to show the prostate glands. Ventral side below.  $\times$  204 diam.
- „ 6. Median sagittal section through the region of the genital opening.  $\times$  73 diam. The vas deferens opens into the genital atrium in the next section.
- „ 7. Section of the hinder extremity of the body at a right angle to the posterior border, to show the structure of the sucker.  $\times$  73 diam.

### HEXACOTYLE GROSSA.

- Fig. 8. One of the intestinal trunks near its hinder end, in a surface view.  $\times$  73 diam.
-

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int.

int.

pt.

int.

v.def.

ut.

reg.can.

int.

int.

diag.mus

central.

mus.

4.

int.

int.

chit

chit.

4.

dorsal.

6.

a.

c.

c'

2

6.

v.def.

int.

ut

reg

8.

3.

1.

c.

a.

c.

c.

b.

c.

d.

d.



PLATE XIII.

## Plate XIII.

### HEXACOTYLE ACUTA.

- FIG. 1. The whole worm viewed from the ventral side. From a specimen killed under a slight pressure.
- „ 2. Hooks at the posterior extremity of the body.  $\times 204$  diam.
- „ 3. Chitinous pieces of the posterior sucker.  $\times 204$  diam. *a*, flat at the anterior end; *b*, flat at the middle; *c*, flat at the posterior end.

### HEXACOTYLE GROSSA.

- FIG. 4. The whole worm viewed from the ventral side. Nerve yellow; excretory vessel indigo-blue.
- „ 5. Hooks at the posterior extremity of the body.  $\times 204$  diam.
- „ 6. Chitinous pieces of the posterior sucker. *a*, *b*, *c* as in fig. 3.
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*John. 10. 10.*

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PLATE XIV.

## Plate XIV.

### HEXACOTYLE ACUTA.

- Fig. 1. Central part of the genital organs, viewed from the ventral side.  $\times$  about 50 diam.
- „ 2. A small portion of the mesenchyma, from the lateral part of the body.  $\times$  204 diam.
- „ 3. Section through the vagina.  $\times$  204 diam.
- „ 4. Same as fig. 1 ; showing the ducts.
- „ 5. Terminal part of the genital ducts, viewed from the ventral side.  $\times$  50 diam.

### HEXACOTYLE GROSSA.

- Fig. 6. A small portion of the mesenchyma, from the lateral part of the body.  $\times$  204 diam.
- „ 7. Central part of the genital organs, viewed from the ventral side.  $\times$  73 diam.
-





PLATE XV.

## Plate XV.

### ONCHOCOTYLE SPINACIS.

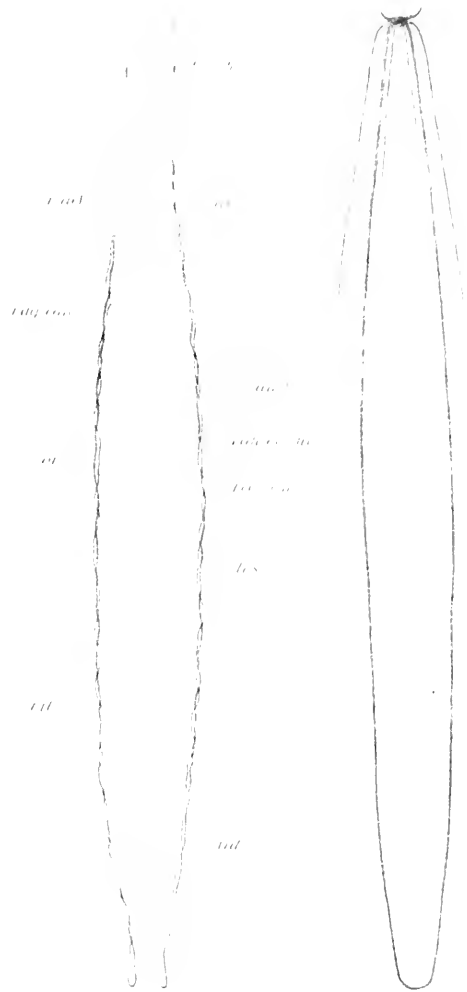
- Fig. 1. The whole worm viewed from the dorsal side; from a specimen killed free with hot sublimate. With the main excretory vessels.
- „ 2. The same in outline, with the nervous system.
- „ 3. Median sagittal section through the anterior end of the body.  $\times 204$  diam.
- „ 4. Cross-section of the anterior sucker through the beginning of the posterior one-third of its length.  $\times 204$  diam.
- „ 5. One of the hooks at the extremity of the caudal appendage.  $\times 305$  diam.
- „ 6. Ovarian ova near the oviduct end.  $\times 204$  diam.
- „ 7. Cross-section of the intestine.  $\times 204$  diam.
- „ 8. Cross-section of one of the posterior suckers.  $\times 73$  diam. *chit'*, space left by the breaking away of the chitinous supporting rod.
- „ 9. Chitinous supporting rod of the posterior sucker.  $\times 204$  diam.
- „ 10. Median portion of a cross-section of the body (22nd section behind the genital opening).  $\times 204$  diam.
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# PLATE XVI.

## Plate XVI.

### ONCHOCOTYLE SPINACIS.

- Fig. 1. Cross-section through one of the bifurcated ends of the caudal appendage, to show the structure of the small sucker.  $\times 204$  diam.
- „ 2. Sagittal section through the same.  $\times 204$  diam.
- „ 3. Cross-section of the body through the region of the ootyp.  $\times 73$  diam.
- „ 4. A portion of the section represented in fig. 3.  $\times 204$  diam.
- „ 5. Cross-section of the uterus near the ootyp.  $\times 204$  diam.
- „ 6. Cross-section of the uterus more removed from the ootyp.  $\times 204$  diam.
- „ 7. Median sagittal section through the region of the genital opening.  $\times 204$  diam. Only the ventral side is represented in detail.
- „ 8. Median portion of a cross-section of the body not much removed from the genital opening.  $\times 204$  diam.
-

2

7

7

7

8



PLATE XVII.

## Plate XVII.

### MONOCOTYLE IJIMAE.

- Fig. 1. The whole worm viewed from the ventral side; from a specimen killed under the pressure of a cover-slip. The body is therefore represented a little broader than it really is. With the nervous system shaded with parallel lines.
- „ 2. The same with the excretory system.
- „ 3. A portion of the radial section of the posterior sucker along one of the radial spokes.  $\times 305$  diam.
- „ 4. Cross-section of the body and sucker through the stalk of the latter.  $\times 73$  diam.
- „ 5. Median sagittal section of the same.  $\times 73$  diam.
- „ 6. A small portion of the part marked *gl.* in fig. 5, to show the sticky glands.  $\times 305$  diam.
- „ 7. Striated muscular fibres of the sucker.  $\times 305$  diam.
- „ 8. Cross-section of one of the radial spokes of the posterior sucker.  $\times 305$  diam.
- „ 9. A small portion of a horizontal optic section of the sucker.  $\times 305$  diam. The white irregular patches represent the optic sections of the muscular fibres.
- „ 10. One of the hooks of the sucker.  $\times 305$  diam.
- „ 11. A small portion of the intestinal epithelium in surface view.  $\times 305$  diam.
- „ 12. A portion of the cross-section of the body through the stalk of the sucker.  $\times 204$  diam. To show the sticky glands (*gl.*) and their common efferent duct (*gl'*).
-

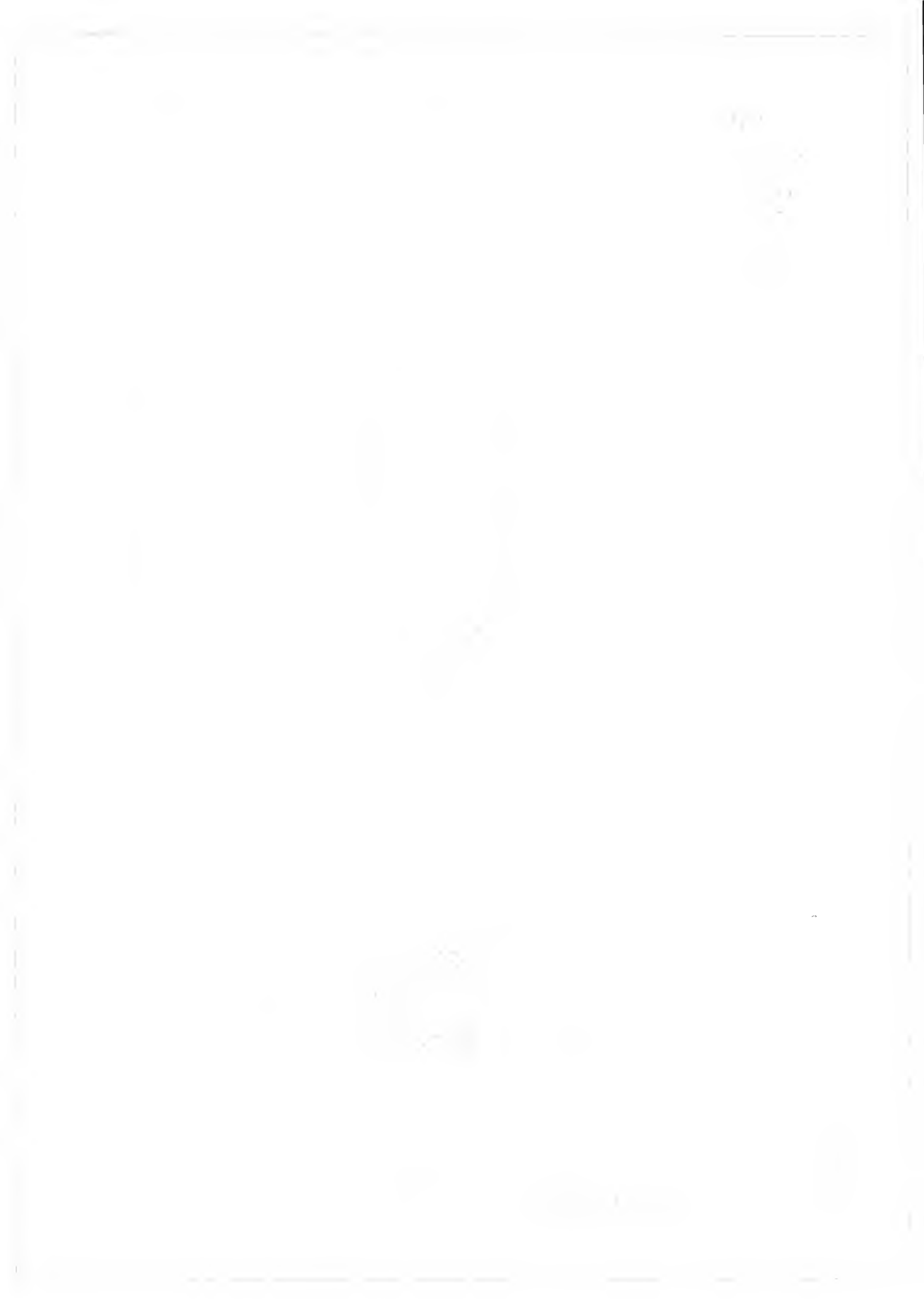






PLATE XVIII.

## Plate XVIII.

### MONOCOTYLE IJIMAE.

- Fig. 1. A portion of the cross-section of the body through the level at which the oviduct is continued into the ootyp.  $\times 305$  diam.
- „ 2. Median portion of a cross-section of the body through the ootyp.  $\times 204$  diam.
- „ 3. A portion of the median sagittal section of the body through the region of the common genital opening.  $\times 204$  diam. *ac*, a circular vessel which surrounds the *bulbus ejaculatorius*.
- „ 4. An almost median sagittal section of the anterior part of the body.  $\times 73$  diam. *a*, ventral lip.
- „ 5. Cross-section of the body through the beginning of the intestinal trunks  $\times 204$  diam.
- „ 6. Section of the ovary near the oviduct end.  $\times 305$  diam.
- „ 7. Chitinous penis.  $\times 305$  diam.
- „ 8. Cross-section of the pharynx.  $\times 204$  diam.
-





PLATE XIX.

## Plate XIX.

### CALICOTYLE MITSUKURII.

- Fig. 1. The whole worm viewed from the ventral side.
- „ 2. The same viewed from the dorsal side.  $\times$  about 5 diam.
- „ 3. The same viewed from the ventral side.  $\times$  about 5 diam.
- „ 4. Foremost portion of the body, viewed from the ventral side.  $\times$  29 diam.
- „ 5. Hook of the same very nearly in profile.  $\times$  73 diam.
- „ 6. Sagittal median section of the posterior sucker.  $\times$  29 diam.
- „ 7. Sagittal median section of the body through the region of the ootyp.  $\times$  73 diam.
- „ 8. Sagittal median section of the foremost portion of the body; composed from four sections.  $\times$  73 diam.
- „ 9. A small portion of the mesenchyma with vitellarium; from a sagittal section.  $\times$  305 diam.
- „ 10. Terminal portion of the male genital duct viewed from the ventral side.  $\times$  204 diam.
- „ 11. An almost median sagittal section of the penis bulb with the basal part of the chitinous penis.  $\times$  305 diam. The two large cells drawn below are probably the prostate glands.
- „ 12. Cross-section of the glandular portion of the vaginal canal.  $\times$  305 diam.
- „ 13. Ovarian ova from the oviduct portion of the ovary.  $\times$  305 diam.

### CALICOTYLE KROYERI.

- Fig. 14. Hook in profile.  $\times$  204 diam. Drawn for the sake of comparison.
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# PLATE XX.

## Plate XX.

### TRISTOMUM SINUATUM.

- Fig. 1. The whole worm viewed from the ventral side. The vitellarium is represented only on one side, and the nervous and excretory systems on the other. Nervous system shaded with parallel lines; excretory system shaded darkest.
- „ 2. One of the hooks of the posterior sucker.  $\times 204$  diam.
- „ 3. Chitinous corpusele at the opening of the lateral gland.  $\times 204$  diam.
- „ 4. Three elevations of the posterior sucker at the point of their junction, in a surface view.  $\times 204$  diam.
- „ 5. Cross-section of the posterior sucker through its stalk.  $\times 29$  diam.
- „ 6. A small portion of the radial section of the posterior sucker transversely to the long axis of the body.  $\times 204$  diam.
- „ 7. A small portion of the tangential section of the posterior sucker.  $\times 73$  diam.
- „ 8. A portion of the cross-section of the body at the level of the oesophagus, to show the salivary glands.  $\times 73$  diam.
- „ 9. Two cells of the salivary gland.  $\times 127$  diam.
- „ 10. A portion of the cross-section of the anterior sucker of the right side and of the adjoining part of the body.  $\times 204$  diam.
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# PLATE XXI.

## Plate XXI.

### TRISTOMUM SINUATUM.

- Fig. 1. Median sagittal section of the anterior part of the body.  $\times 73$  diam.
- „ 2. A small lateral portion of a horizontal section of the body; to show the marginal sticky glands and their ducts.  $\times 204$  diam.
- „ 3. A small lateral portion of a cross-section of the body; to show the opening of the marginal sticky glands.  $\times 204$  diam.
- „ 4. A small ventral portion of a cross-section of the body.  $\times 204$  diam.
- „ 5. A portion of a horizontal section of the body just behind the pharynx.  $\times 204$  diam.
- „ 6. Cross-section of the oviduct at the point of its junction with the ootyp; to show the opening of the shell-glands.  $\times 204$  diam.
- „ 7. Beginning of the yolk-duct.  $\times 427$  diam.
- „ 8. ; Principal part of the female genital organs viewed as a transparent object from the ventral side.  $\times 44$  diam.
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# PLATE XXII.

## Plate XXII.

### TRISTOMUM SINUATUM.

- Fig. 1. A small portion of a horizontal section of the body near the terminal portion of the vas deferens.  $\times 204$  diam. To show the prostate glands.
- „ 2. A small portion of a horizontal section of the body near the genital opening.  $\times 50$  diam.
- „ 3. Horizontal section through the ootyp and the adjoining parts.  $\times 204$  diam.
- „ 4. Submedian section of the penis; from a horizontal section of the body.  $\times 204$  diam.
- „ 5. A small ventral portion of a cross-section of the body through the yolk-reservoir.  $\times 204$  diam.
- „ 6. A section through the right, hinder eye-spot and the adjoining parts of the brain.  $\times 427$  diam.
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PLATE XXIII.

## Plate XXIII.

### TRISTOMUM OVALE.

- Fig. 1. The whole worm viewed from the ventral side. The testes are represented only on one side.
- „ 2. One of the hooks of the posterior sucker.  $\times 70$  diam.
- „ 3. Tangential section of the marginal membrane of the posterior sucker.  $\times 204$  diam.
- „ 4. Median sagittal section through the region of the pharynx.  $\times 50$  diam.
- „ 5. Cross-section through the region of the left anterior sucker.  $\times 50$  diam.
- „ 6. Cross-section through the anterior part of the pharynx.  $\times 50$  diam.
- „ 7. A small portion of the ventral side of a cross-section of the body.  $\times 204$  diam. The contents of the testes are only partially drawn.
- „ 8. Central portion of the genital organs viewed as a transparent object from the ventral side.  $\times 29$  diam.
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PLATE XXIV.

## Plate XXIV.

### TRISTOMUM OVALE.

- Fig. 1. A small portion of the wall of the penis in longitudinal section.  $\times 204$  diam.
- „ 2. A small ventral portion of a cross-section of the body.  $\times 204$ . The reference lines for *l. mus.* and *diag. mus.* should reach more inward, the latter to the oblique lines next the *cir. mus.*, and the former to the numerous closely crowded dots next the foregoing.
- „ 3. Cross-section of the left anterior eye and its vicinity.  $\times 427$  diam.
- „ 4. Cross-section of the left posterior eye.  $\times 427$  diam.
- „ 5. Two nerve-cells from the brain.  $\times 427$  diam.

### TRISTOMUM ROTUNDUM.

- Fig. 6. The whole worm viewed from the ventral side. On the right side the testes are shown only in outline, and the vitellarium is wholly omitted.
- „ 7. Three chitinous corpuscles from the margin of the body.  $\times 204$  diam.
- „ 8. One of the hooks of the posterior sucker.  $\times 204$  diam.
- „ 9. Central part of the genital organs viewed from the ventral side.  $\times 29$  diam.

### TRISTOMUM FOLIACEUM.

- Fig. 10. The whole worm viewed from the ventral side. The vitellarium is not shown on the right side.
- „ 11. Hooks of the posterior sucker.  $\times 204$  diam.
- „ 12. Median sagittal section of the anterior part of the body.  $\times 73$  diam.
-





PLATE XXV.

## Plate XXV.

### TRISTOMUM NOZAWAE.

- Fig. 1. The whole worm viewed from the ventral side ; the vitellarium is represented only on one side.
- „ 2. One of the hooks of the posterior sucker ; a small portion was broken off during preparation.  $\times 204$  diam.
- „ 3. Central portion of the reproductive organs viewed as a transparent object from the ventral side.  $\times 75$  diam.

### TRISTOMUM BIPARASITICUM.

- Fig. 4. The whole worm viewed from the ventral side ; the vitellarium is represented only on one side.
- „ 4a. An egg-shell.  $\times 50$  diam.
- „ 5. One of the chitinous corpuscles of the lateral margins of the body.  $\times 204$  diam.
- „ 6. Hooks of the posterior sucker, from the same pair.  $\times 204$  diam.
- „ 7. Median sagittal section of the body through the region of the pharynx.  $\times 73$  diam.
- „ 8. Central portion of the genital organs viewed as a transparent object from the ventral side.  $\times 50$  diam.

### TRISTOMUM FOLIACEUM.

- Fig. 9. Central portion of the genital organs viewed as a transparent object from the ventral side.  $\times 73$  diam. A part of the vas deferens has been omitted to make place for the prostate glands.
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PLATE XXVI.

## Plate XXVI.

### EPIDELLA ISHIKAWAE.

- Fig. 1. The whole worm viewed from the ventral side ; from a specimen killed free.  
The nervous system is shaded with parallel lines.
- „ 2. Hooks of the posterior sucker.  $\times 204$  diam.
- „ 3. The genital organs, vitellarium exclusive, viewed from the dorsal side.  
 $\times 50$  diam.

### EPIDELLA OVATA.

- Fig. 4. The whole worm viewed from the ventral side ; from a specimen killed free.  
 $\times 50$  diam.
- „ 5. Hooks of the posterior sucker.  $\times 204$  diam.
- „ 6. The genital organs, vitellarium exclusive, viewed from the dorsal side.  
 $\times$  about 73 diam. *x*, an organ of problematic nature.
- „ 7. Cross-section of the penis.  $\times 204$  diam. The cavity of the penis lies  
above *duc. ej.*
- „ 8. Section through one of the organs of problematic nature shown in fig. 6,  
with some of the histological elements in its vicinity.  $\times 204$  diam.
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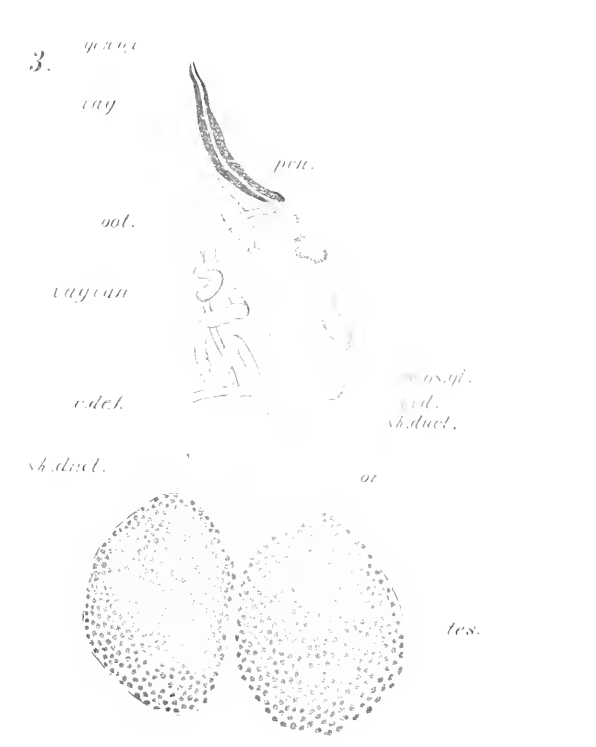
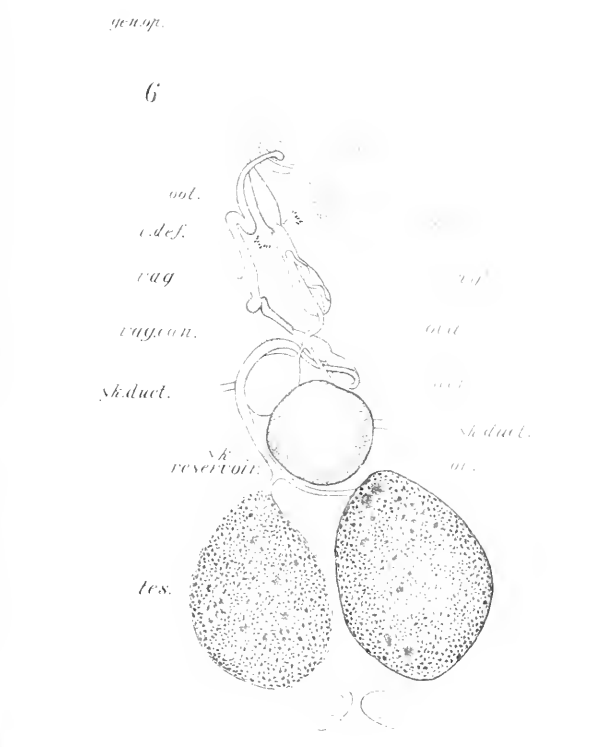
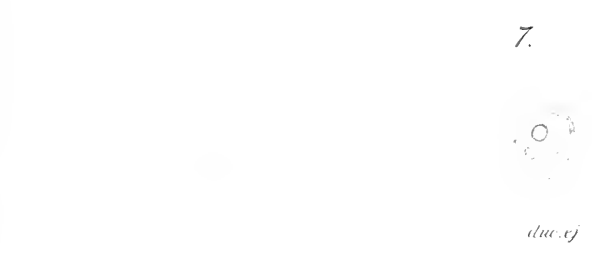
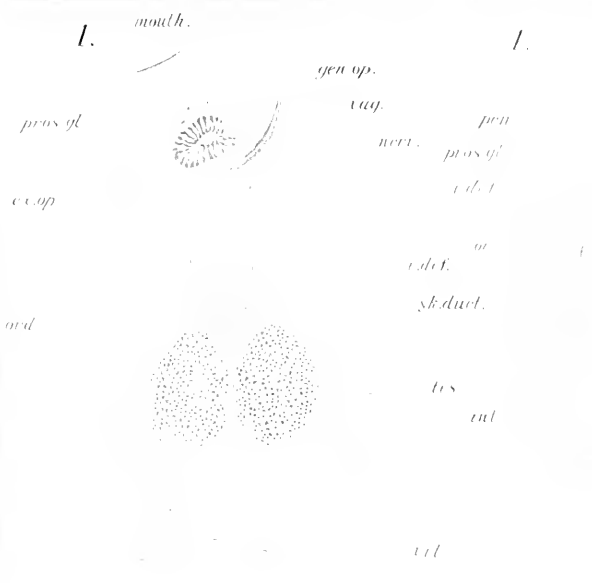




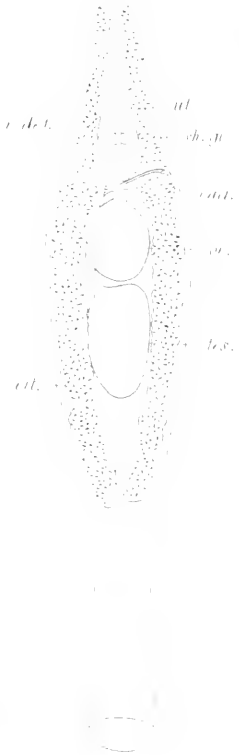
PLATE XXVII.

## Plate XXVII.

Diagrams intended to show the homology of the genital ducts in the Trematodes and the Cestodes. Homologous ducts are coloured alike.

- Fig. 1. *MICROCOTYLE*; dorsal view.  
„ 2. *DISTOMUM*; dorsal view. Based on the figures of Leuckart and Ijima.  
„ 3. *DACTYLOGYRUS*; dorsal view.  
„ 4. *AMPHILINA*; ventral view. Based on the figure and description of Monticelli.  
„ 5. *CARYOPHYLLAEUS*; ventral view. After Monticelli.  
„ 6. *TAENIA*; ventral view. After Leuckart.  
„ 7. *BOTHRIOCEPHALUS*; ventral view. After Leuckart.
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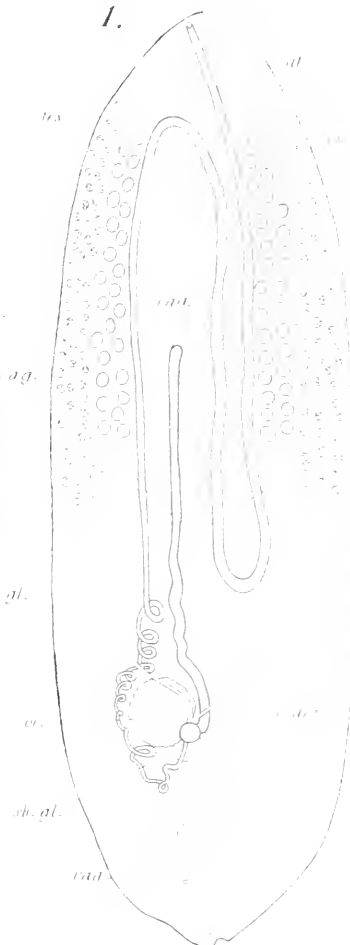
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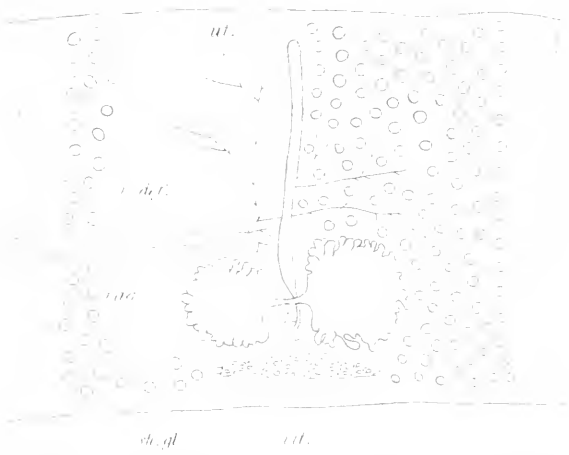
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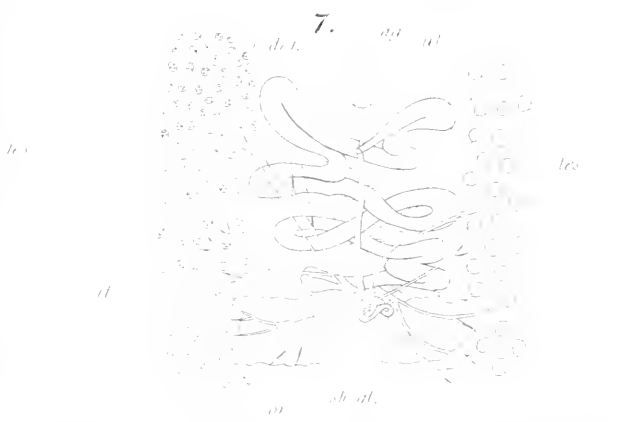
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# On some new Japanese Land Leeches.

(*Orobdella* nov. gen.)

By

Asajiro Oka, *Ph. D.*

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With Plates XXVIII-XXX.

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Whilst examining a small collection of Japanese leeches in the Museum of the Zoological Institute of this University, my attention was attracted by some specimens of land leeches, totally different from *Hemadipsa japonica* Whitman, and since all that was known of this interesting group of animals, as it occurs in this country, was confined to the single species just mentioned, I set to work to investigate these new forms thoroughly.

The collection contained only 17 specimens, but to these I was able to add others from various localities, from time to time, so that now I have in all 31 specimens kept in alcohol, and have, besides, cut 10 others into sections in order to examine their internal structure. An account of their external characters, and a general outline of their internal organisation are presented in this paper.

They are so much alike in external features, that at first I took them all to belong to one species, and ascribed the slight but apparent differences between some of them to a difference of age. A minute study of them, however, convinced me that I had three distinct species before me, and that these were

members of a genus separated, more or less widely, from all the genera of land leeches that had been then defined.

They decidedly form deviations from the generally accepted rule, that in *Gnathobdellidae*, each unabbreviated somite consists of five rings. We know, indeed, at present, thanks to the untiring researches of Dr. R. Blanchard of France, one genus of *Gnathobdellidae* which has only three rings in a complete somite, and two others from the Family, *Herpobdellidae* (Syn. *Nephelidae*), which have respectively six and eight rings in a somite. Moreover, some specimens of *Trocheta* from the Crimea were found to have as many as eleven rings in each complete somite. Such being the case, the leeches I am going to describe are not the only instances, in which a somite consists of a number of rings other than five. What is striking in them, however, is that the number of rings in a complete somite is not even constant within the limit of the genus, though constant in each species. Besides, these new land leeches exhibit many other peculiarities, so that an account of them should certainly not be without interest both to systematists and to those investigators who are occupied with the external morphology of the order *Hirudinea*.

I take the opportunity here of expressing my heartiest thanks to Prof. Mitsukuri for affording me various conveniences for investigation and to Prof. Ijima for kindly placing at my disposal a specimen out of his own collection. For a number of specimens I am indebted to Prof. Nakagawa of Kumamoto, who collected them for me during his stay among the Nikko mountains.

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So far as I am aware, there are only five well established genera of the Order *Hirudinea*, whose members are exclusively terrestrial, viz.: *Hamadipsa*, *Xerobdella*, *Mesobdella*, *Cylicobdella* and *Lambricobdella*.

*Hæmadipsa* Tennent (1861), which is found in Ceylon, India, Burma (1894), and Japan (1886), may be regarded as a terrestrial representative of the medicinal leech, being so nearly allied to the latter that both were long known under the common generic appellation of *Hirudo*. In fact, *Hæmadipsa* differs from *Hirudo* only in those points, that are most likely to be influenced by change of habit. They agree in having three toothed jaws and five pairs of eyes, and differ only in the number of suppressed rings at both extremities of the body. The second genus, *Xerobdella* von Frauenfeld (1868), is closely allied to the preceding one. It has three toothed jaws, like *Hirudo* and *Hæmadipsa*, but differs from them both in having four pairs of eyes instead of five. This genus is characterised, further, by the presence of a pair of tentacle-like appendages at the anterior extremity of the body. The only species, by which this genus is represented, *Xerobdella Lecomtei* von Frauenfeld (1868), has hitherto been found only in the mountainous parts of Europe. The third genus, *Mesobdella* R. Blanchard (1893), is certainly the most remarkable of all the land leeches. It occupies a place in between the two natural divisions of *Hirudinea*. While it agrees with the Gnathobdellids in possessing ten eyes and three denticulated jaws, each of its somites consists of three rings and its intestine is provided with a number of large lateral blind sacs, as is the case in the Rhynchobdellids. This genus is represented, like the preceding one, by only one species, which is a native of Chili. The two remaining genera *Cylicobdella* Grube (1871) and *Lumbricobdella* Kennel (1886), both of which are confined to South America and the West Indies, form a group to themselves, in contrast with the remaining land leeches. They are found in the same localities and closely resemble each other externally. They have both no eyes and no jaws. One of them, *Lumbricobdella*, has no acetabulum. Their internal organisation shows that they are to be placed in the Family

*Herpobdellidae*. It is very interesting to notice that *Lambricobdella Schafferi* Kennel has 262 rings counted on the ventral side, a number which clearly shows, that we have in this animal another example of a leech with more than five rings in each somite. How many external rings come to one somite in this case was, however, not ascertained by Kennel.

A form of land leech from Australia is mentioned by Whitman (1886) under the name of *Geobdella* (nec *Geobdella* de Blainville, 1828). This genus is very nearly allied to *Hæmadipsa*, but differs from it in having only two jaws, and also in the fact that the genital openings are separated by seven and a half rings instead of five. So far as I know, this leech was only briefly referred to by the same author in speaking about the Japanese land leech, and we do not even know what specific name he gave to the Australian animal.

The existence of still another land leech is recorded by Forbes (1890) from North America. It is a species of the genus *Semiscolex* Kinberg, whose members are generally aquatic. According to the description given by Forbes, this genus seems to be very nearly related to, if not identical with, the well-known genus *Hemopsis* Savigny (1820) (Syn. *Aulostoma* Moquin-Tandon, 1826).

The new genus of Japanese land leeches, for which I propose the name of *Orobdella*,<sup>1</sup> may be characterised as follows :

*Orobdella* nov. gen.

*Body*, almost cylindrical, more or less flattened toward the hind extremity ; the lateral margins of the body nearly parallel for the greater part of the length ; slightly tapering toward both ends.

*Rings*, differing in number according to the species, but constant

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<sup>1</sup> Όρος mountain, βδέλλα leech ; leech inhabiting mountains.

for each ; the surface of the rings quite smooth, destitute of any protuberances ; the furrows between the rings distinct but not deep.

*Somites.* Number of the rings in an unabbreviated somite variable, but constant for each species (4, 6, or 8).

*Mouth-opening* occupying, on the ventral side, a space corresponding to 4-6 rings, at the anterior extremity of the body ; the two following rings forming, on the ventral side, the posterior lip of the mouth.

*Eyes.* Only one pair externally visible, situated always at the anterior margin of the second ring, wide apart from each other. A few minute black dots sometimes visible on the 4th or 5th ring.

*Maxillæ.* Entirely wanting.

*Genital Orifices.* The male orifice is placed about the middle point between the 5th and the 6th ganglia (not counting the œsophageal ganglionic mass). The female orifice is situated just in front of the 7th ganglion. The number of rings which intervene between these two orifices variable, but constant in each species.

*Clitellum* occupying a space of three somites' length, *i. e.*, the two somites bearing the genital orifices, a greater portion of the somite preceding them, and a few rings of the somite following them.

*Nephridial pores* opening on the ventral surface of the last ring of the somites.

*Acetabulum* rather small, ovate, the diameter being less than half the breadth of the animal.

As I have only alcoholic specimens, now, I am unable to give an exact description of the colour of all these leeches in the living state, but judging from a water-colour drawing made from the fresh object and also from specimens that had been kept only for a short time in alcohol, the following may be said of all three species. The dorsal surface is always darker than the ventral. The median line of the dorsal

surface is the darkest. The dorsal surface is divided indistinctly into three longitudinal areas, one broad median and two narrow lateral. The lateral areas, as well as the whole ventral surface, are of a pale orange colour. The median area of the dorsal surface is of different colours according to the species, and also even to the individual (olive green, grayish, bluish red).

The land-leeches of the genus *Orobdella* are found in various mountainous parts of Japan. The localities, where the specimens in my collection come from, are Kioto, Gifu, Hakone, Nikko, and Kibōzan near Kumamoto. They are found crawling under moss and fallen leaves or in moist earth, in the same manner as earthworms, which constitute the chief source of their nourishment. Being possessed of no jaws these leeches have no power of biting and consequently of sucking blood. They go about in pursuit of earthworms and swallow them entire, as I have repeatedly found by dissection. My sections of these leeches show sometimes the peculiarity of presenting the structure of two worms at once, that of the leech and that of the earthworm swallowed. With regard to habits, therefore, *Orobdella* has almost nothing in common with *Hamadipsa*, but rather resembles *Cylicobdella* and *Lumbricobdella*.

The *Orobdelle* are pretty large leeches, most of the specimens that were found mature being more than 10 cm in length. Among the collection there is an extraordinary large one preserved in alcohol that measures more than 27 cm.

Before proceeding to the description of the individual species, I may here say something about the methods followed by different authors in counting the rings and determining the boundary of the somites. According to the method proposed by Whitman (1884), the rings are counted on the dorsal surface, beginning with the first oculiferous ring. This is certainly very simple, and has hitherto been

followed by Blanchard (1892, etc.) but we have then to disregard wholly that portion of the body lying in front of the first pair of eyes. Kennel (1886), in describing the land-leeches of South America, counts the rings on the ventral side, beginning with the first complete ring behind the posterior margin of the mouth, but this method is still less satisfactory than the first one, especially when we want to mark precisely the position of the eyes or some other organs in the head region. Lastly, Apathy (1888) counts every ring in the body, whether in front of the first pair of eyes, or behind it. As this method seems to be the least artificial, I have followed it in the present paper, as well as in my former articles on leeches. It need not be added, that in so doing I do not necessarily attribute to each apparent ring at the anterior extremity of the body, the value of one morphological ring.

In studying the external morphology of ten-eyed leeches, Whitman (1885) points out the occurrence of certain segmental sense-organs on the first ring of every somite. If this were the case throughout the whole Order, the determination of the boundary of somites would not have been a very difficult task. But, there are a great many genera and species, in which, as in *Orobdella*, all the rings constituting a somite look exactly alike, so that the method proposed and carried out by Whitman can not always be applied with success. In such forms, Blanchard (1892 &c.) used the nephridial pores alone as the starting point for the determination of the somites. In the following diagnoses, I fixed the number of rings in a complete somite in each species, by means of the position of the nephridial pores and the nervous ganglia, and for the determination of the numerical order of the somites I counted them forward and backward from the genital openings, whose position had been previously ascertained by dissection.

*Orobdella Whitmani*\* (Ijima MS) nov. sp.*Diagnostic Characters.*

*Body* nearly cylindrical, somewhat flattened toward the hind end, tapering slightly toward the head.

*Rings* 88, distinctly marked. Behind the last complete ring, there is still one more which is distinctly visible only on the dorsal side.

*Somite*, when complete, consisting of 4 rings.

*Mouth* occupying a space corresponding to the 4 foremost rings; 5th and 6th rings forming on the ventral side the posterior lip of the mouth.

*Eyes*, in one pair, at the anterior margin of the 2nd ring; on the 4th ring a pair of small pigment dots, representing rudimentary eyes.

*Genital orifices.* The male orifice is situated on the ventral surface of the 27th ring, the female orifice on the 32nd; 4 rings between the rings bearing them.

*Uterellum*, embraces 12 rings, beginning with the 22nd and ending with the 33rd.

*Acetabulum*, ovate, small, the diameter measuring nearly half the breadth of the animal.

*Anus*, on the dorsal surface of the acetabulum, about one ring's breadth behind the posterior margin of the last ring.

*Nephridial pores* hardly visible externally, opening in the median portion of the body on every fourth ring, on the ventral surface more or less distant from the lateral margins.

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\* This, as well as the following specific names, is constructed in strict accordance with the 'Règles de la Nomenclature des êtres organisés' published lately by the Société Zoologique de France.



There are in my collection 18 specimens of this leech, of which 14 are adults. The dimensions of the three largest specimens are as follows :

Length,	107 mm.	103 mm.	80 mm.
Width,	11 mm.	10 mm.	7.5 mm.
Depth,	6.5 mm.	6.5 mm.	6.5 mm.

In smaller specimens, the difference between the two last dimensions is less obvious, so that their body has exactly the same form as the earthworm.

Of the external rings, the 3rd and the last rings present peculiarities, in so far as the former is divided on the dorsal surface by a furrow into two unequal parts, and the latter is distinct only on the dorsal side. On passing over to the ventral surface, the last ring enters into the formation of the acetabulum, so that, if counted on the ventral side, the latter organ comes next to the penultimate ring.

As concerns the colour, this species exhibits great variability. While the larger specimens obtained from Kiōto are decidedly greenish on the dorsal side, as shown in the Fig. 1 (Pl. XXVIII), all the smaller ones from various other localities are of a bluish-red colour. There are still others, whose dorsal surface is brownish or greyish.

There being no segmental papillæ, which distinguish some of the rings from the rest and are of great use in determining the boundary of the somites, we have no other method of counting the somites than by examining the internal organs. As already noticed, I began by ascertaining the topographical relation of the external rings to the nervous ganglia, which exhibit the metameric arrangement more regularly than any other organ. There are in this species, as in all other known *Hirudinea*, twenty one ventral ganglia, not counting the oesophageal and the acetabular ganglionic masses. A median longitudinal section of the whole animal hardened in alcohol shows most clearly, that, of

these twenty-one ganglia, fifteen at least are situated at an interval of four rings from each other. This regular arrangement of the ganglia, taken together with the fact that the nephridial pores open on every fourth ring, admits of no doubt that in this species an unabbreviated somite consists of four rings, although this number has never been recorded for any leech, whether a Rhynchobdellid or a Gnathobdellid. The sections show also that the ring, on which the nephridial pores open, immediately precedes the one containing the ganglion. This leads us to the conclusion that, in this leech also, the ganglion lies in the first ring, and the nephridial pores open on the last of each somite, as is actually the case in every other Gnathobdellid.

The specimens of this species were collected at Kinkwazan near Gifu (Nawa), at Chi-on-in in Kiōto (M. Kikuchi) and at Kibōzan near Kumamoto (Nakagawa).

*Orobdella Ijimaï* nov. sp.

*Diagnostic characters.*

*Body* subcylindrical, slightly tapering toward both ends.

*Rings* 129 ; a few of the last rings again divided by furrows.

*Somite*, when unabbreviated, consisting of 6 rings.

*Mouth*, occupying a space corresponding to the 5 foremost rings ; 6th and 7th rings forming on the ventral side the posterior lip of the mouth.

*Eyes*, in one pair, at the anterior margin of the second ring.

*Genital orifices.* The male orifice is situated on the 39th ring, the female orifice on the 47th ; 7 rings between those bearing the genital pores.

*Clitellum* embracing 19 rings, beginning with the 31st and ending with the 49th.

*Acetabulum*, small, ovate, the diameter measuring about one-half the width of the animal.

*Anus*, on the dorsal surface of the acetabulum, about one ring's breadth behind the posterior margin of the last ring.

Of this leech there are 10 specimens in my collection. Only 4 of them are mature. The dimensions are as follows :

Length,	78 mm.	77 mm.	72 mm.	68 mm.
Width,	6 mm.	5.5 mm.	5 mm.	6 mm.
Depth,	4.5 mm.	4.5 mm.	4.5 mm.	4 mm.

By comparing the rings of this species with those of *Orobdella Whitmani*, the specimens being of equal length, the respective breadths of the rings are found to be in the proportion of 2 to 3. In the head region, this difference is not so obvious.

In determining the number of rings in a complete somite, I followed exactly the same method as in the last species. After opening the animal from the dorsal surface the position of the ganglia was carefully marked out by means of pins in order to ascertain which rings contained them. It became very evident that one ganglion was allotted to every 6 rings. The nephridial pores open on every sixth ring too.

In colour, this leech reminds us immediately of the earthworm. The dorsal surface is of a reddish grey colour, sometimes varying to a pale blue. Near the lateral margins of the body, the colour becomes lighter by degrees and goes over to the pale whitish colour of the ventral surface. There are also specimens in which the lightening of the colour is less gradual, so that the dorsal surface looks to be of the same dark colour all over except at the margins where it is whitish.

All the specimens we have of this leech were collected at Nikkō (Ijima, Nakagawa). They are found generally in localities where earthworms abound, and on account of similarity in colour, are very liable to be mistaken for the latter.

*Orobdella octonaria* nov. sp.*Diagnostic Characters.*

*Body*, subcylindrical, more or less flattened toward the hind end ; lateral margins parallel except near the extremities.

*Rings*, 171.

*Somite*, when unabbreviated, consisting of 8 rings.

*Mouth*, occupying a space corresponding to the 6 foremost rings ; 7th and 8th rings forming, on the ventral side, the posterior lip of the mouth.

*Eyes*, in one pair, situated at the anterior margin of the second ring, near the lateral borders of the anterior lip of the mouth.

*Genital orifices*. The male orifice is on the 51st ring, the female orifice on the 62nd ; 10 rings are between the rings bearing them.

*Clitellum* embraces 24 rings, beginning with the 41st and ending with the 64th.

*Acetabulum*, small, the diameter less than one-third the width of the animal, in large specimens hardly of any suction function.

*Anus*, on the dorsal surface of the acetabulum, about a rings breadth behind the posterior margin of the last ring.

This species is represented in my collection by three specimens only, whose dimensions are as follows :

Length,	270 mm.	130 mm.	80 mm.
Width,	14 mm.	9 mm.	12 mm.
Depth,	10 mm.	6 mm.	5 mm.

In this species the rings show sometimes a tendency to be divided into secondary rings by means of shallow grooves. Toward both extremities, especially at the head end, we find also many rings that are double on the dorsal surface but single on the ventral. In the above diagnosis, such rings are counted as separate. The breadth of a

ring in the middle portion of the body is only one-half that of a corresponding ring of *Orobdeella Whitmani*. and, in consequence, the animal appears very finely annulated.

That in this species each complete somite consists of eight rings was very easily shown by the method I had used for the other two. For this purpose, the two larger specimens were cut open from the dorsal surface, and the position of the nervous ganglia was carefully examined. In both of them, I could demonstrate most clearly that, in the median portion of the body, every eighth ring lodged a ganglion. The nephridial pores could not be recognised externally in the two smaller specimens, but they were visible in the largest one. They open, in the middle part of the body, on every eighth ring too, and each of these rings immediately precedes one containing a ganglion. Thus, and by comparing this with other leeches, it becomes clear that the groove between the ring that bears the nephridial pores and that lodging the ganglion, is the boundary between two somites. Toward both extremities of the body, where abbreviation of the rings takes place, this regularity comes naturally to an end.

This species is certainly one of the largest leeches that are known. A specimen preserved in alcohol, and in a state of contraction at two places, measures a little more than 270 mm. It therefore far surpasses in length the largest leech hitherto described, *Hæmenteria Ghiliani* de Filippi (1849), concerning which de Filippi made the following remark: "Cette espèce doit figurer au nombre des plus grandes sangsues; en effet l'exemplaire dans l'alcool mesure 0 m.135 en longueur, et 0.05 en largeur; et lorsqu'il était vivant, inasi que Mr. Ghiliani m'a dit, il s'allongait jusqu'à un pied de Paris." A specimen of *Orobdeella octonaria*, which measures nearly as much in a somewhat contracted state, must have surely been longer at least by half that dimension when fully stretched.

The specimens of this leech were collected at Kinkwazan near

Gifu (Nawa) and in the Hakone mountains. The specimen from Gifu shows the tendency toward a farther division of the rings much more distinctly than the other two which were brought from Hakone.

*External Morphology.*

It is very interesting to notice that the three species described above bear a striking resemblance to each other in external features, in spite of the great difference in the number of the rings. The position of the eyes and the genital orifices is coincident in all the species. The number of rings that intervene between those bearing the genital orifices is different according to the species, but if we disregard the external rings and take only the somites into consideration, these openings are found to be situated in the corresponding portion of the corresponding somites. In the Figs. A, B, & C (Pl. XXIX.) I have tried to show the relation of the rings to the somites, in the different species, which might be summed up in tabular form as follows :

		<i>Or. Whitmani</i>	<i>Or. Ijimai</i>	<i>Or. octonaria</i>
I-VI	somites	12 rings	17 rings	22 rings
VII-XXIII	„	$17 \times 4 = 64$ „	$17 \times 6 = 102$ „	$17 \times 8 = 136$ „
XXIV-XXVI	„	8 „	10 „	13 „
Total number		88 „	129 „	171 „

Although the body of *Orobdeella* appears to have a uniform structure throughout its whole length, except at the acetabulum, we can still recognise in it, by careful examination, a certain number of regions. These are not, in fact, so apparent in our leeches as in some other forms, such as *Branchellion* and *Ozobranchus*, in which some of the regions are easily distinguishable externally, but as they present differences not only with regard to the internal organisation, but also to the constitution of the somites, they must be treated separately in the consideration of the external morphology.

Apathy (1888) and Lang (1891) divide the body of a leech into

the following regions; cephalic, clitellar, median, anal, and acetabular. These five regions are also recognisable in the case of *Orobdeella*, but as the boundary between them can not be fixed but arbitrarily, I thought it better not to adopt Apathy's method strictly. In the following, the external characters of the three species of *Orobdeella* will be treated successively from the head end toward the acetabulum, without putting thereby any accurate boundary between the regions above mentioned.

*Head.* There is no distinct line of limit that separates the head region from the rest of the body. As in all Gnathobdellids, this region passes by insensible gradations into the clitellar region, but we may regard, perhaps, the head proper as ending with the rings that form the posterior margin of the mouth. The triangular portion of the body that lies in front of the eyes was counted, in the diagnosis of the species, as the first ring, although not considered as such by some authors (Blanchard, Whitman). The second ring is characterised in all the species by the presence of two distinctly visible, yet inconspicuous, eyes; this makes it very probable, that the second ring is homologous throughout. The third ring is very broad in *Orobdeella Whitmani* and is divided into two unequal portions by means of a transverse furrow; the anterior portion is as broad as the fourth ring, while the posterior is only of half that breadth. This ring of *Orobdeella Whitmani* seems to correspond to the third and fourth rings of *Orobdeella Ijimai*. The fourth ring of *Orobdeella Whitmani* and the fifth ring of *Orobdeella Ijimai* have two minute black dots, situated near the lateral margins of the body and representing rudimentary eyes. When viewed from underneath, the head region looks nearly the same in all the species. The whole ventral surface of this region as far as the fifth, sixth, or seventh ring, according to the species, is occupied by a wide mouth, much like the same organ of *Cylicobdella* or *Lumbricobdella* in Kennel's figures (1886). The two rings that form the posterior boundary of

the mouth are always distinct, but the furrow that separates them on the ventral surface is much less conspicuous than the one following it.

The portion of the body directly following upon the head proper may be called the neck. In this region, there seems to occur some abbreviation of the somites, though not to the same extent as in the head. Owing, however, to the completely uniform appearance of the rings, I am not able to give the manner in which this abbreviation takes place.

*Clitellum.* The number of the rings embraced by the clitellum is, in the three species of *Orobdella*, 12, 19, and 24 respectively. This difference is caused, not by the difference of their relative positions, but solely by the difference in the number of rings in a complete somite. In all the species, the clitellum occupies a space corresponding to three somites in length. In *Orobdella Whitmani* and *Orobdella octonaria* the number of rings in the clitellum is exactly three times that in a somite. In *Orobdella Ijimai* there is one ring more. The position of the clitellum in relation to the somites can clearly be understood from Pl. XXIX, where the corresponding somites of the three species are placed side by side. The somites X and XI, that bear the genital orifices are completely included in the clitellum, while the somites IX and XII are only partly taken in in the formation of the fore and hind portions of that organ. The somite IX has 3, 5, or 6 rings modified, according to the species. In the somite XII only one or two rings are modified, all the remaining rings lying outside the clitellum.

That in *Orobdella Ijimai* the clitellum embraces one ring too many to correspond exactly to three somites in length, seems to be worth notice. As may be understood from the figures in Pl. XXIX, the furrows that form the boundary of clitellum in *Or. Whitmani* and *Or. octonaria* fall upon the rings 31 and 49 in *Or. Ijimai*. Now, as a ring



can not be partly outside, and partly inside the clitellum, the rings mentioned are wholly taken in by it. Hence it follows, that in this species the clitellum embraces one ring more than the others.

*Genital pores.* The genital orifices are situated in the X and the XI somite respectively. The position which they occupy in these somites is the same in the three species. If we assume each of these somites to be divided into eight rings, as is actually the case with *Orobdeella octonaria*, we find the male opening always on the fifth ring of the X somite and the female opening on the last ring of the XI. The number of the rings that separate those bearing the genital orifices is 4, 7, and 10, respectively, but this difference results again, as in the case of the clitellum, from the difference in the number of rings that make a complete somite in these species. If we put the external rings out of consideration, these orifices are found to occupy the corresponding portions of the corresponding somites. This very interesting point in their position can easily be understood by referring to the figures A, B, and C, in Pl. XXIX. The unmistakable coincidence among the species in regard to the position of the genital openings, as well as to that of the clitellum, speaks strongly for the near relationship of these three kinds of land-leeches.

*Median region.* It is in this region that the somites show their external constitution most clearly and without any abbreviation. As has been already stated, the leeches belonging to the present genus have no segmental papillæ that make the somites externally distinguishable, and we are compelled to refer to the internal anatomy for ascertaining their boundaries. This, however, is not very difficult in the median region, where each of the rings lodging the ganglia comes next to that on which the nephridial pores open. A comparison with other leeches belonging to the sub-order *Arhynchobdellæ* of Blanchard, tells us that the furrows between these two sorts of rings mark the limits of

the somites. By dissection, a ring that lodges a ganglion can easily be determined, and starting from it we are able to find the boundaries of the somites in a considerable portion of the body, though at the two extremities, it is almost impossible to group the rings into somites appropriately.

By this means, I found out that the three species above described had somites consisting of four, six, and eight rings, respectively. To those authors who lay much weight on the number of rings constituting a somite, from a systematic point of view, it might seem quite strange, that species differing so much should be placed in one and the same genus. But as these leeches agree in almost every other character than that of the number of the rings, I think it quite natural to regard them as members of a genus.

*Hind end.* The hind end presents some peculiarities that are common to all the three species. The anus opens on the dorsal surface of the acetabulum, about a ring's breadth from the posterior margin of the last ring. This latter is distinct only on the dorsal side, but enters into the formation of the acetabulum on the ventral side. Where the anus opens is marked by a transverse furrow, and in *Or. octonaria* there is still one more furrow behind the anus, so that we are apt to reckon the dorsal surface of the acetabulum as rings, if we count on that side. Thus it is clear that in these species the acetabulum is not so distinctly marked from the body as in other genera. Fig. 14, Pl. XXVIII, is a sketch of the hind end of a very large specimen of *Or. octonaria*, natural size, and serves to show that the acetabulum is here, comparatively, very small. The mode of life of these leeches seems to make the suctory function of the acetabulum less necessary, and the growth of this organ does not accompany that of the body, after the animal has attained a certain dimension.

*Number of somites.* By dissection we find that there are twenty-

one ganglia in the ventral chain, not counting the nerve-mass at the fore and hind extremities. Analogous to all other genera of leeches hitherto investigated, the œsophageal ganglionic mass is composed of 5 ganglia, that are clearly distinguishable, and some groups of ganglionic cells representing perhaps the rest of another ganglion. The acetabular nervous mass is made up of 7 ganglia. Adding these numbers together, we have the total of 33, a number that holds good for every member of the *Gnathobdellidae* as well as of *Rhynchobdellidae*. Thus *Orobdella* agrees with all other leeches in regard to the fundamental plan of the nervous system and consequently to the number of the somites.

#### *Anatomy.*

*Integument.* The body is enveloped in a thin layer of chitinous substance, the cuticle, under which lies a single layer of columnar cells, the epidermis. There are many unicellular glands scattered over the whole surface, some of them lying much deeper than the rest. Among the columnar cells of the epidermis, or passing through them, are found networks of capillaries, that run parallel to the external surface of the animal, in the same manner as indicated in the figures of the medicinal leech by Prof. Lankester. Within the clitellar region the number of deep-lying glands is decidedly greater than at other localities of the body.

*Mouth-cavity.* As these leeches are destitute of toothed jaws, the mouth leads directly into the mouth cavity, which forms an enormous space reaching behind the XIII somites (Pl. XXX, Fig. 3). In cross sections, this cavity has a triangular outline (Pl. XXX, Fig. 4) and shows, besides, some small shallow grooves on each side. Circular muscle-fibres are pretty well developed around the cavity. The salivary gland opens mostly into the anterior portion of this cavity,

but there are many of such openings scattered in the hinder part also. In form and relative size, the mouth cavity of *Orobodella* approaches that of the *Cylicobdella* and *Lumbricobdella*.

*Stomach.* I have examined this organ in two of the species only, namely, *Or. Whitmani* and *Or. Ijimai*; whether this organ exhibits the same character in *Or. octonaria*, I am not able to tell. In the two species that I examined, the stomach presents no difference in its general plan of structure. It is a tubular organ, the wall of which is irregularly folded, the folds being generally caused by the presence of dorso-ventral muscle-fibres. Near the hind end, where this organ communicates with the intestine, it gives off two large blindsacs, one on each side (Pl. XXX, Fig. 2). Behind this point, the stomach becomes narrower and forms a sort of funnel that opens into the next section of the alimentary canal. In the number of blind sacs of the stomach, these two species agree with *Lumbricobdella*. In many of the specimens I found pieces of earthworms in the stomach, sometimes as long as the stomach itself. From this it follows, that the mouth and the wide œsophagus serve only for swallowing, or at the most, for cutting the worms into large portions, which are then sent into the stomach whole.

*Intestine.* The epithelial lining of the intestine can easily be distinguished from that of the stomach by the greater height of the individual cells, which is double or more that of the cells of the latter organ. With hæmatoxylin the wall of the intestine is stained much deeper than that of the stomach. From the appearance of the contents, it might be judged that the stomach is an organ for reserving and digesting the nourishment, while the intestine is entirely devoted to its absorption. The numerous deep folds that increase the surface, and the blood vessels that surround the intestine closely, may also be looked upon as data for the above statement.

*Vascular system.* With regard to the vascular system, *Orobdella* seems to occupy an intermediate position between *Hirudo* and *Herpobdella* (syn. *Nephelis*). There are four main trunks of blood vessels, that correspond to the dorsal, lateral, and ventral vessels of *Hirudo* respectively, but the blood spaces that are found anastomosing between various organs are comparatively very wide and present characters similar to those of *Herpobdella*. The wall of the lateral vessels is furnished with muscles, which makes it most probable that these vessels pulsate in the living state. The dorsal trunk is not so conspicuous as the lateral ones, having no muscular layer in its wall.

In every somite of the median portion of the body, there is one pair of large irregularly spherical blood-spaces, in which the funnels of the nephridia open. In *Herpobdella* there are two pairs, but in *Orobdella* I could find but one pair. The position of these spherical sinuses is nearly the same in the two genera; in *Orobdella* they seem to be a little nearer the ventral surface of the body than in *Herpobdella*. The blood-spaces receive their blood from the lateral vessels by means of very short transverse vessels, of which one pair is found in each somite.

*Nephridia.* The funnel that opens into the blood-space consists of five or six cells, forming so many spoon-shaped lobes arranged radially. Upon this funnel follows a capsule filled with small cells, analogous to that of *Glossosiphonia* (syn. *Clepsine*) (1894) but not so well developed. The funnel is thickly ciliated over the whole surface, and the lumen opens freely into the interior of the capsule. How this latter organ communicates with the remaining sections of the nephridium I am at present unable to tell, but it is probable that the intracellular canal of the nephridial string stands in connection with the lumen of the capsule. The beginning of the nephridial string certainly lies directly in contact with the wall of the capsule. The winding of the

canal is very nearly allied to that in *Herpobdella*. In both genera the nephridial canal consists of a large number of cells arranged in a single row, and perforated in the direction of the row so as to form drain pipes. For the greater part of the length, where two or three rows of cells come to touch each other, these pipes coalesce, the boundary between their walls becomes less distinct, and the whole structure appears in sections, as if it consisted of only a single row of cells perforated by two or three canals. In this respect, what I described for *Glossosiphonia* applies equally well to *Orobdella* or *Herpobdella*. A figure of the nephridium of *Herpobdella octoculata* (Linné) 1758 (= *Nephelis vulgaris* Moq.-Tand. 1827) as reconstructed from sections by A. Graf (1893), represents the canal as running from the capsule to the bladder in a simple course, but this is decidedly false. In *Herpobdella* as well as in *Orobdella*, the canal makes at least three loops, and those portions of the different loops that come to run parallel to each other coalesce in the manner above described.

At the distal end of the nephridial canal there is a bladder-like dilatation lined with ciliated epithelium. Its shape is generally conical with the apex pointing toward the integument (Fig. 4., Pl. XXX). Whitman (1886) found that the land leech he investigated had large bladders as compared with the medicinal leech, and expressed the opinion that the large size of these organs is probably a result of adaptation to the terrestrial mode of life. As this seemed very interesting, I examined the bladder of *Orobdella* in comparison to that of *Herpobdella*, which is undoubtedly its nearest aquatic ally, but my results were all negative. *Orobdella* has only as large bladders as *Herpobdella* or even smaller than them. It is not, therefore, every form of terrestrial life that causes the enlargement of bladder but only a certain kind of terrestrial life. There are essentially only two different modes of life among the land leeches, one represented by *Haemadipsa* and

the other by *Orobdella*. If we consider the extreme difference in the mode of life of these two genera of leeches, it is no wonder that a terrestrial abode works on various organs differently in the animals in question.

The bladder does not open directly on the outside of the integument. A portion of the epidermal layer forms a tube-like invagination at the place where the bladder opens, and serves as an evacuator canal. Vejdoský (1883) stated that nephridial bladders are present in all the genera of leeches, even in *Glossosiphonia*, but here he reckoned this tubular portion of the dermal epithelium for the bladder, which itself is wanting. In *Orobdella* this portion is of an insignificant length and might very easily be overlooked.

*Testes.* The male genital elements are formed in spherical capsules arranged longitudinally on both sides of the ventral nerve-chain. There are generally 90-100 pairs of such capsules. In this respect *Orobdella* finds its nearest ally in *Lumbricobdella* which, according to Kennel (1886), has about 90-93 pairs. These capsules are divided into groups of nine or ten by the forebranch of the lateral nerves and the nephridial bladder (Fig. 8, Pl. XXX). Each capsule is lined by flat cells all around, except at one point where the testis communicates with the vas deferens. Here, the cells forming the wall of the capsule become higher and columnar and form a sort of ciliated funnel with the narrower end opening into the vas deferens. This latter duct runs along the outer side of the row of capsules, and after making several convolutions at the front end, joins the vas deferens of the other side and finally opens into the cavity just within the external male orifice.

About the female genital organ I have nothing specially to mention. *Orobdella* seems to be protandrous, the ovaries ripening much later than the testes. In young specimens the ovaries are very

small and the egg-cells are scarcely larger than the cells of the ovarian wall, while the spermatozoa are already distinctly formed.

*The eyes.* The structure of the eyes of *Orobiddella* agrees almost in every point with that of *Macrobiddella* communicated by Miss Merrill (1894). "The visual cells are arranged in a single layer around the axial nerve-fibres. The symmetry of this arrangement is broken at the upper end and on one side by a multiplication of the visual cells, so that the layer there may be two or three cells thick.....The visual cells contain a large crescentic or horse-shoe shaped vacuole surrounded by a layer of protoplasm, in the most thickened part of which the small nucleus is placed, as first pointed out by Prof. Whitman. The visual cells are surrounded by the pigment layer.....Over the top and at the side of the pigment cup, the epidermal cells become elongated to two or three times their normal length."

As indicated in the figure, the nerve is divided into two branches before it enters the eye. One of these branches forms the axis for the visual cells, while the other runs along the outside of the pigment cup, gives off some fibres to the scattered visual cells and ends in the cells of the epidermal layer. This peculiarity was already described by Maier (1892).

If we examine *Orobiddella* externally, we find only one pair of eyes, but the sections show that there are 4 pairs of undeveloped eyes beside them, forming in all 5 pairs. It is the second pair that is externally visible. The 1st, the 3rd, and the 4th pairs of eyes have no pigment at all. The 5th pair has a small quantity of pigment, which is sometimes visible externally as minute black dots. The direction of the axis around which the visual cells are arranged is not the same in all of the five pairs. The axes rather radiate from a certain point situated in the front portion of the head-region, as pointed out by Apathy (1888 a) for the eyes of *Hirudo*.



*Morphology of the first ring.* That part of the body lying in front of the externally visible pair of eyes consists of one ring in *Orobdeella*. This ring is however in reality the product of coalescence of a certain number of rings. That this apparently single ring is composed of at least two rings is very clearly shown by the position of the first pair of rudimentary eyes (Fig. 1, Pl. XXX). The well-developed pair of eyes of *Orobdeella* corresponds, thus most probably to the first pair of eyes of *Xerobdeella Lecomtei* (1892) and to the second pair of *Hemadipsa*. In such forms as the members of *Hirudinea*, where the metameric structure of the body is modified at both ends in consequence of the division of labour, the number of the rings counted in those parts is only descriptive and should not be looked upon as data for ascertaining the homology of the rings.

*Comparison with other land-leeches.*

All the genera of land-leeches, including *Orobdeella*, may be arranged in two groups, namely, the one containing *Hemadipsa*, *Mesobdeella*, *Xerobdeella*, and the other containing *Cylicobdeella*, *Lumbricobdeella*, and *Orobdeella*. The leeches of the first group are characterised by the presence of toothed jaws and by the semi-parasitic mode of life. They have well developed acetabulum and 4-5 pairs of eyes, that are distinctly visible externally. The second group contains, on the other hand, all those forms destitute of jaws. They live in moist localities, such as under fallen leaves and mosses or among rotten wood, and hunt after earthworms. The acetabulum is small or entirely wanting. There is only one pair of distinct eyes or none at all.

If we compare *Orobdeella* with *Hemadipsa*, we see at once how the different mode of life works differently on the general form of the body. The one living upon trees and dropping unperceived on persons or animals that pass under them, has a comparatively small and

very soft body attenuated toward the head, with a very well developed acetabulum. The other having large mouth and hunting after earth-worms has a long cylindrical body of nearly the same thickness throughout, and not so soft and distensible as that of former. The acetabulum is comparatively of little use in moving under mosses and is consequently on the way to disappear. The most important difference from the morphological point of view is in the number of rings that make one complete somite, which is 5 in *Haemadipsa* and 4, 6, or 8 in *Orobdella*.

The two forms of land-leeches from Trinidad reported by Kennel (1886) seem to be the most nearly allied to *Orobdella*. They agree in their mode of life, which brings with it resemblance in the external form of the body. In their internal anatomy too, they present many points of agreement. How far these land leeches resemble each other and how far they differ may be summed up as in the following table:

	<i>Cylicobdella</i>	<i>Lumbricobdella</i>	<i>Orobdella</i>
Body :	cylindrical.	cylindrical.	subcylindrical.
No. of rings :	98-100.	262.	A. 88, B. 129, C. 171.
No. of rings in a somite :	—	—	A. 4, B. 6, C. 8.
Eyes :	0	0	2.
Jaws :	0	0	0.
Acetabulum :	present.	wanting.	present; very small.
Length of the oesophagus :	$\frac{1}{3}$ the body-length.	$\frac{2}{3}$ body-length.	$\frac{1}{3}$ body-length.
Dorsal blood vessel :	wanting,	wanting,	present.
No. of round blood-sinuses in a somite :	1.	1.	1.
Nephridial funnel :	wanting,	wanting,	present.
Testes :	12 pairs,	90/93.	90-100 pairs.
No. of intesti- nal blind-sacs:	1, or wanting.	2.	2.

*Orobdella* agrees with *Lumbricobdella* in the number of the intestinal blind-sacs, and in that of the testicular capsules, differing from it, however, in the presence of the acetabulum. As some of the larger specimens of *Orobdella* have also a very diminutive acetabulum, the difference mentioned should not be regarded as being of such weight as to interfere seriously with the affinity of these two genera. Thus, *Orobdella* finds its nearest ally among the known leeches in *Lumbricobdella*.

#### *Systematic Position.*

The division of *Hirudinea* into two families, *Gnathobdellidæ* and *Rhynchobdellidæ* is very natural and already universally adopted, but the diagnostic characters for them have generally been based exclusively upon their well-known European representatives. Thus, for instance, Apathy (1886) gives the following three points as the distinctive marks for *Gnathobdellidæ*: “1. Der Oesophagus hat einen geraden Verlauf, ohne vorstreckbaren Saugstecher. 2. Das typische Mittelkörpersomit besteht aus 5 Ringen. 3. Die äusseren Nephridialaperturen befinden sich an dem Hintersaume des 5. Ringes, und zwar, mit Ausnahme von *Haemadipsa* an der Bauchfläche.” In order to receive *Orobdella*, which can belong to no other family, two out of these three points must be erased. It is the first one only, that holds good for *Orobdella*, the second is wholly untenable, and the third has to be corrected thus:—“The external apertures of the nephridium are found at the posterior margin of the *last* ring.” That they open on the ventral surface has no value whatever for diagnosis, for, so far as I know, there is no leech that has nephridial openings on the dorsal surface. Apathy divides *Gnathobdellidæ* further into two subfamilies; *Nephelidæ* and *Hirudinidæ*. This is also very reasonable, but the characters he gives to *Nephelidæ* are too limited to admit any other forms

than the genus *Nephelis*. They are as follows:—"Die Zahl der vollständigen Somite des Körpers ist 19. Die Zahl der gesammten Ringe bis zur Haftscheibe 113 (resp. 109); die 101 Ringe, welche vom hintersten Augenpaar bis zur Analapertur gezählt werden können, sind leicht wahrnehmbar. Die Geschlechtsöffnungen sind von einander durch zwei Ringe getrennt. Auf dem VI. Somit sind nie von Augen vorhanden. Die Afteröffnung befindet sich zwischen dem ersten and zweiten Somit der Region. Die Mundöffnung erstreckt sich vom II. bis IV. Somit. Die Hinterlippe wird von dem Ringe vor dem 3. Augenpaar gebildet." It will be seen at once, that none of these characters applies to *Orobdelella*.

Quite lately R. Blanchard (1894) has published an important paper on the leeches of Italy, in which he classifies them according to a new system. His classification seems to me by far more rational than the one hitherto employed, so that I do not hesitate in adopting it. I reproduce here briefly those passages that concern the classification of our new land leeches.

First of all, the Order *Hirudinea* is divided into two sub-orders, namely *Rhynchobdelle* and *Arhynchobdelle*. The *Orobdelella* fall naturally into the latter group, of which the author gives the following diagnosis.

### Arhynchobdellæ.

*Hirudinea proboscide carentia, maxillis armata aut inermia, sanguine rubro, aquas dulces colentia vel terrestria. Corpus elongatum, vermiforme, quandoque subteres. Capula ventralis, a corpore non distincta, supra segmentata oculosque vario numero ferens. Os in fundo capulae. Cotyla disciformis a corpore distincta, maxima parte sub ventra recondita. Corpus e 26 somitis constans, extremis contractis. Clitellum a somitis IX-XI formatum. Nephridiorum 17 paria post somitos VI-XXII defluentia. An-*

*nulorum numerus integro apud varia genera differt. Primus annulus somiterum tam ventre quam dorso papillis segmentariis vario numero prebet. Porus genitalis masculus in somito X, vulva in somito XI hians. Ora in capsulis posita, centri non adhaerentia.*

The sub-order is again divided into two families, *Gnathobdellidae*, and *Herpobdellidae*. The latter family, to which *Orobdella* belongs, is characterized thus :

### Fam. Herpobdellidæ.

*Gula maxillis dentatis carens, quandoque tribus pseudognathis chitinosi inermibus ornata, uno medio infero, duobus lateralibus superis. Oculi 8 in duas series a pluribus annulis separatas dispositi, constantesque e duobus paribus anterioribus et duobus paribus posterioribus. Papille segmentarie permulte, non appretentes. Annuli 5-11 in somito integro, saepius dispares. Pori nephridiales in latere ventris hiantes. Intestinum cecis lateralibus carens. Ora pauca in capsulis ellipticis complanatis pellucidis lapidibusque vel herbis adherentibus posita. Habitat aquas dulces.*

After describing the external features and the internal organisation of *Cycticobdella lumbricoides* Grube, *C. coccinea*, and *Lumbricobdella Schöfferi*, Kennel (1886) makes the following remark : " Aus der vorstehenden Beschreibung der drei Arten von Erdegeeln geht hervor, dass dieselben zu der Gruppe von Hirndineen zu rechnen sind, welcher unsere *Nepheleis* angehört ; der Mangel der Kiefer, das Fehlen der segmentalen Darmaussackungen und des dorsalen Blutgefäßes, die schlauchförmigen Ovarien, der Mangel eines rutenförmigen Begattungsorganes, der compacte Bau der Muskulatur stimmen im Allgemeinen mit *Nepheleis* überein." And my investigation on *Orobdella* leads me to the conclusion that I have to make almost the same remark concerning this leech, which can belong to no other family than *Herpobdellidae*.

The Family *Herpobdellidae* counts, thus, at least six genera, *Herpobdella*, *Dina*, *Trocheta*, *Cyclobdella*, *Lumbricobdella*, and *Orobdella*. To include all these genera, the above diagnosis must be altered in regard to the number of eyes and to the habit. It will run as follows:—*Hirudinea*, without proboscis, without jaws; eyes in less than 5 pairs or wholly wanting; rings without external marking that distinguishes some from the rest; number of rings in a complete somite 5–11. The other minute characters are important only in determining the genera.

The position which *Orobdella* occupies in the order *Hirudinea* is, according to the results of my investigations, that shown in the adjoining synoptical table.

Ordo. *Hirudinea*

a. Subordo *Rhynchobdellæ*

b. Subordo *Arhynchobdellæ*

1. Fam. *Gnathobdellidæ*

Aquatic: gen. *Hirudo*, *Hæmopsis*, *Limnatis*, &c.

Terrestr.: gen. *Hæmadipsa*, *Xerobdella*, *Mesobdella*.

2. Fam. *Herpobdellidæ*

Aquatic: gen. *Herpobdella*, *Dina*, *Trocheta*

Terrestr.: gen. *Cylicobdella*, *Lumbricobdella*,

***Orobdella*.**



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PLATE XXVIII.

## PLATE XXVIII.

- FIG. 1. *Orobolletta Whitmani*. nat. size.  
FIG. 2. *Orobolletta Ijimaï*. nat. size.  
FIG. 3. *Orobolletta octonaria*. nat. size.  
FIG. 4, 5, 6. Head of *Orobolletta Whitmani*.  $\times 3$ .  
FIG. 7, 8. Hind end of *Orobol. Whitmani*.  $\times 3$ .  $\alpha$ , anus.  
FIG. 9, 10. Head of *Orobol. Ijimaï*.  $\times 3$ .  
FIG. 11. Head of *Orobol. octonaria*.  $\times 3$ .  
FIG. 12. Hind end of *Orobol. octonaria*.  $\times 3$ .  
FIG. 13. Head of a large specimen of *Orobol. octonaria*. nat. size.  
FIG. 14. Hind end of the same. nat. size.
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PLATE XXIX.

## PLATE XXIX.

A. *Orobol. Whitmani*.

B. *Orobol. Ijimaë*.

C. *Orobol. octonaria*.

cl., elitellum.

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PLATE XXX.

## PLATE XXX.

- FIG. 1. Horizontal section of Head region of *Orobd. Whitmani*.  $\times 23$ . *oe.* eyes.  
*oc.* mouth-cavity. *n.* nerve.
- FIG. 2. Horizontal section of *Orobd. Ijimaï*.  $\times 23$ . *st.* stomach. *cac.* blind sacs.  
*int.* intestine.
- FIG. 3. Sagittal section of the front end of *Orobd. Whitmani*.  $\times 5$ .
- FIG. 4. Cross section of *Orobd. Whitmani*.  $\times 23$ . *vd.* dorsal vessel. *oc.* mouth-cavity. *vl.* lateral vessel. *nph.* nephridium. *nph.* bladder of nephrium.  
*vr.* ventral vessel. *n.* nerve.
- FIG. 5. Sagittal section of the eye of *Orobd. Ijimaï*.  $\times 300$ . *n.* nerve. *cr.* visual cells.
- FIG. 6. Section through the spherical dilatation of blood sinus, with the nephridial funnel in it. *sv.* blood sinus. *inf.* nephridial funnel.
- FIG. 7. Section through a testicular capsule.  $\times 300$ . *sp.* group of spermatozooids.
- FIG. 8. A portion of horizontal section of *Orobd. Ijimaï*.  $\times 55$ . *vr.* ventral vessel.  
*n.* nerve. *tes.* testes. *nph.* nephrial bladders.
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ÉTUDES  
SUR  
LA FÉCONDATION ET L'EMBRYOGÉNIE  
DU  
GINKGO BILOBA (1)

PAR  
Sakugorô HIRASE

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AVANT-PROPOS.

Au sujet de la fécondation et de l'embryogénie du *Ginkgo biloba*, M. le Prof. EDUARD STRASBURGER a exposé ses belles observations en 1872 dans son grand ouvrage, «*Die Coniferen und die Gnetaceen*», puis en 1879 dans son ouvrage classique, «*Die Angiospermen und die Gymnospermen*», et enfin en 1892 dans son important ouvrage, «*Histologische Beiträge Heft IV*». Il ne m'a pas paru pourtant que ses travaux, bien que fort remarquables, avaient épuisé la question et n'avaient rien laissé à étudier. Remplir autant que possible certaines lacunes qui resteraient encore, c'est le but de mes recherches, qui ont

(1) La Note préliminaire de ce travail a paru dans «*The Botanical Magazine*» publié par la Société botanique de Tôkyô, Vol. IX, No. 100, 1895.

été commencées, il y a quelques années, suivant le conseil de M. le Prof. S. Ikeno au Collège d'Agriculture.

Tous mes matériaux d'étude ont été récoltés sur un grand arbre cultivé au Jardin Botanique de notre Université. Des fruits en ont été récoltés à partir du milieu de juin jusque vers la fin d'octobre une ou deux fois par semaine ou même une fois par jour vers la saison de fécondation. Après avoir été coupés en pièces de presque 3 millimètres cubes, ils ont été fixés par un des trois réactifs suivants, savoir l'alcool absolu, le liquide de Merkel et celui de Flemming, ce dernier m'a donné de meilleurs résultats. Les coupes épaisses de 12 à 15  $\mu$  ont été pratiquées d'ordinaire à l'aide d'un microtome et, après la coloration, ont été montées au baume. Quant aux réactifs colorants, je me suis servi entre autres de l'hématoxyline de Böhmer, de la fuchsine acide à 0,2 p. 100, d'un mélange de fuchsine acide et du vert d'iode, de la fuchsine acide et du vert de méthylène (successivement appliqués), et enfin de la fuchsine acide et du bichromate de potasse (suc. app.)

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## 1. DÉVELOPPEMENT DE L'OOSPHERE.

La pollinisation du *Ginkgo biloba* a lieu vers la fin d'avril. Au milieu de juin, ses fruits grossissent beaucoup et alors on reconnaît déjà au sommet du sac embryonnaire primaire deux ou trois archégones, chacune pourvue de ses deux cellules du col. Le noyau au sein de l'oosphère se trouve entouré d'une enveloppe de cytoplasma, qui même se relie au revêtement pariétal au moyen des filets cytoplasmiques (Pl. XXXI, fig. 1).

A mesure que l'oosphère se développe, le noyau augmentant de volume de plus en plus se rend le long du revêtement cytoplasmique pour arriver enfin sous le col ; on rencontre parfois vers le milieu de



juin l'oosphère dont le noyau est encore en voie de se transporter (Pl. XXXI, fig. 2). Quant au cytoplasma, il est plein de vacuoles, sauf une petite portion au-dessous du noyau et le bord de l'oosphère. Ici le cytoplasma est d'une nature assez dense et parsemé çà et là de grosses granulations ressemblant beaucoup à des grains d'aleurone en apparence; les plus grosses se trouvent notamment sous le noyau et on en rencontre quelques-unes coulant hors de l'oosphère (la figure 3 de la Pl. XXXI représente un cas très remarquable). Les granulations et le cytoplasma augmentent peu à peu pendant quelques semaines, de sorte que vers la fin d'août l'espace entier de l'oosphère finit par être occupé, à part quelques vacuoles, par le cytoplasma parsemé partout de granulations. Le noyau acquérant alors sa dimension définitive (le diamètre étant au plus de 92 à 94  $\mu$ ), sa portion vis-à-vis des cellules du col devient un peu convexe. Il arrive souvent que cette portion se contracte et laisse un espace vacant entre elle et les cellules du col (Pl. XXXI, fig. 4), ce qui tient peut-être à la fixation incomplète des matériaux. Aux premiers jours de septembre, le noyau se rapproche très près des cellules du col; de grosses granulations dans l'oosphère disparaissent, et enfin le cytoplasma finit par être rempli, non plus de grosses granulations, mais de granulations beaucoup plus fines (Pl. XXXII, fig. 8); et alors le développement complet de l'oosphère est achevé.

A ce sujet-là, M. STRASBURGER a énoncé qu'elle se remplit lentement de cytoplasma (1), mais il ne me semble qu'il ait décrit les granulations déjà indiquées. Grâce à mes observations dans un grand nombre de préparations, j'ai été amené à reconnaître qu'il existe une relation fort intime entre l'apparence des granulations et le remplissage de l'oosphère de cytoplasma. Quant à l'origine et la nature de ces

(1) *Die Coniferen und die Gnetaceen*, 1872, p. 291.

granulations, nous y reviendrons plus tard, nos recherches étant encore assez incomplètes.

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## 2. FORMATION DE LA CELLULE DU CANAL.

Dans un fruit récolté le 8 septembre, j'ai reconnu dans un même sac embryonnaire les deux oosphères avec leurs noyaux qui sont tous les deux dans la phase du «dispirem» caryocinétique (Pl. XXXI, fig. 7 *a-b*) et c'est assurément une phase de la formation d'une cellule du canal, bien que je ne réussisse pas encore à trouver des phases précédentes de la caryocinèse. Dès que la cellule du canal, représentée par la moitié supérieure du «dispirem» est formée, elle ne tarde pas à se désorganiser et à se séparer de la moitié inférieure, tandis que le noyau de l'oosphère grossit de nouveau et descend vers le sein de l'oosphère (Pl. XXXII, fig. 8).

M. STRASBURGER, qui a fait une étude sérieuse à propos de la formation de la cellule du canal chez le *Juniperus virginiana*, en a donné une figure où l'axe du fuseau nucléaire est incliné sur la gauche vers le bord de l'oosphère(1); de même, il a dit sur ce sujet(2), «Während die Kanalzelle von *Juniperus* sich rasch desorganisirt, rückt der Eikern nach der Mitte des Eies vor». En s'appuyant sur cette observation, il a modifié ce qu'il avait dit auparavant sur le *Ginkgo* et s'exprime de la sorte(3), «Nach dem Beispiel von *Juniperus* möchte ich nun aber annehmen, dass auch hier später dieser Kern (=noyau de l'oosphère) sich theilt, eine Kanalzelle gebildet wird», ce que confirment

(1) *Die Angiospermen und die Gymnospermen.* Taf. XVI, Fig. 5,6.

(2) *Ibid.*, p. 143.

(3) *Ibid.*, p. 148.

mes présentes observations. Donc le fait que la cellule du canal se forme de la même manière chez le *Ginkgo* que chez le *Juniperus* a été suffisamment établi. Il me semble que la figure où se trouve la substance supposée par lui d'abord comme «eine ziemlich stark lichtbrechende Kanalzelle» (1) et reconnue plus tard comme «eine farblose Plasma-Ansammlung» (2) correspond à mes figures 4 et 5, mais il faut remarquer que je ne puis pas trouver cette substance particulière décrite par lui au-dessus du noyau de l'oosphère.

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### 3. FÉCONDATION.

Bien que je n'aie pas été encore assez heureux pour observer la fusion des deux noyaux, mâle et femelle, il faut néanmoins ajouter ici quelques choses sur la fécondation.

Le commencement de la fécondation chez le *Ginkgo* est marqué par ceci que le noyau au sein de l'oosphère grossit beaucoup et que les cellules du col se gonflent outre mesure et se colorent en brun jaunâtre.

J'ai obtenu quelques préparations où on rencontre une masse confuse de substance indistincte dans le cytoplasma à l'extrémité supérieure de l'oosphère. Il est très vraisemblable que cela représente le stade de la pénétration du noyau spermatique dans l'oosphère [correspondant à la fig. 7 de Taf. XVI de M. STRASBURGER représentant le *Juniperus* (3)], mais malheureusement la fixation de mes matériaux en ce cas était tellement insuffisante que je n'avais pas pu trouver le noyau spermatique dans la masse confuse indiquée ci-dessus.

(1) *Die Coniferen und die Gnetaceen*, p. 291.

(2) *Die Angiospermen und die Gymnospermen*, p. 148.

(3) *Ibid.*, p. 49.

#### 4. EMBRYOGÉNIE.

Au sujet de la conduite du noyau de l'oosphère après la fécondation, M. STRASBURGER avait cité en des termes que je demande la permission de répéter ici textuellement(1): «Die Befruchtung beginnt wie bei anderen Coniferen mit der Vergrösserung und Auflösung des jetzt die Mitte des Eies einnehmenden Zellkerns. Derselbe verschwindet und es treten neue Kerne auf».

En 1879, il a modifié cet avis et s'est exprimé comme ci-dessous(2): «Ich glaubte damals annehmen zu müssen, dass der Keimkern aufgelöst wurde; jetzt schliesse ich hingegen aus der allmählichen Vermehrung der Zellkerne, die sich gleichmässig und frei im Protoplasma des Eies vertheilen, auf eine Theilung des Keimkerns und auch fortgesetzte Theilung seiner Nachkommen. Ist die endgiltige Zahl der Kerne erzeugt, so umgeben sie sich mit Plasmastrahlen und es erfolgt zwischen ihnen Scheidewandbildung, ganz wie bei freier Endospermibildung».

Malheureusement l'avis nouveau du savant professeur s'appuie plus spécialement sur l'analogie tirée de la conduite du noyau chez des autres Gymnospermes que sur l'observation directe chez le *Ginkgo* lui-même. Je crois donc qu'il est mieux de vérifier son avis par des observations directes.

Immédiatement après la fécondation, le cytoplasma de l'oosphère devient très riche en grosses granulations et le noyau de l'oosphère se divise en deux. La première bipartition ainsi opérée, chacun des deux nouveaux noyaux ne tarde pas à subir une deuxième bipartition;

(1) *Die Coniferen und die Gnetaceen*, p. 292.

(2) *Die Angiospermen und die Gymnospermen* p. 49.

après quoi il suit une troisième bipartition et ainsi de suite jusqu'à une huitième, après laquelle les cloisons cellulodiques commencent à être formées entre les noyaux ainsi engendrés.

Dans des matériaux récoltés vers le milieu de septembre, j'ai pu observer, outre la phase représentée par la fig. 9 (Pl. XXXII), où se trouve un seul fuseau nucléaire dans l'oosphère, diverses phases de la caryocinèse (Pl. XXXII, fig. 10-11) (1). Aucune des phases observées par moi ne m'a montré des sphères attractives aussi magnifiques que celles que j'ai aperçues dans les cellules génératrices du tube pollinique du *Ginkgo* (2). Ce que l'on peut prendre là pour des sphères attractives n'est représenté que par des rayons étoilés ou de très fines granulations de diverses grandeurs parsemées çà et là irrégulièrement (Pl. XXXII, fig. 10), dont rien n'autorisera à admettre que ce sont des sphères attractives à l'état naturel (3).

Or, on reconnaîtra que pendant cette division répétée, tous les noyaux dans une même oosphère sont toujours au même stade de la caryocinèse; donc il est vraisemblable que les noyaux dérivés du noyau d'une oosphère subissent la bipartition chacun en même temps et que par conséquent leur nombre à un moment quelconque est égal à une certaine puissance du nombre 2. D'où il suit que par le compte de leur nombre dans une oosphère, on pourra connaître combien de fois le noyau de l'oosphère s'est divisé dès le début.

(1) J'ai obtenu quelques préparations montrant les «Knotenpunkte» de M. Strasburger (*Die Coniferen und die Gnetaceen*, Taf. XIII, Fig. 58); il faut remarquer cependant que ces pareilles préparations ont été obtenues des matériaux fixés *incomplètement*. En outre, je ne peux pas encore affirmer si le noyau en repos ou bien celui en division nous montre-t-il cet état abnormal.

(2) S. Hirase, *On the Attraction-Spheres of the Pollen-Cells of Ginkgo biloba*, «*Botanical Magazine*», Vol. VIII, No. 91, p. 259.

(3) Les sphères attractives représentées tout récemment par M. J. Farmer dans les figures photographiques au sujet de la division nucléaire des cellules polliniques du *Lilium* (*Flora, Heft I, 1895*) ressemblent à peu près à celles que j'ai rencontrées dans l'oosphère du *Ginkgo*, mais son avis étant différent en quelques points du mien, je me le réserverai pour le futur.

Le tableau suivant(1) a été fait sur l'observation de quelques dizaines des fruits :—

Nombre des fruits examinés.	Nombre des oosphères examinées.	Nombre des noyaux d'une oosphère.	Numéro de la bipartition.	Nombre des oosphères dont les noyaux se multiplient suivant les puissances de 2.	Nombre des oosphères dont les noyaux se multiplient irrégulièrement.
2	2	1		2	
2	3	$2=2 \times 1$	1 <sup>ère</sup> bipartition	3	
5	11	$4=2^2$	2 <sup>ème</sup> —	11	
1	1	$7=2^3-1$	après la 3 <sup>ème</sup> —		1
2	5	$8=2^3$	3 <sup>ème</sup> —	5	
2	3	$16=2^4$	4 <sup>ème</sup> —	3	
3	6	$32=2^5$	5 <sup>ème</sup> —	6	
1	2	$64=2^6$	6 <sup>ème</sup> —	2	
1	1	$123=2^7-5$	après la 7 <sup>ème</sup> —		1
5	8	$128=2^7$	7 <sup>ème</sup> —	8	
1	1	$133=2^7+5$	après la 7 <sup>ème</sup> —		1
1	2	$255=2^8-1$	après la 8 <sup>ème</sup> —		2
		$(256=2^8)(2)$	(8 <sup>ème</sup> —)		
1	1	$260=2^8+4$	après la 8 <sup>ème</sup> —		1
Total 27	46	...	...	40	6

En consultant ce tableau on verra qu'il y a certaines déviations à la règle de bipartition simultanée énoncée ci-dessus, car les noyaux sont rarement plus (133, 260) ou moins (7, 123, 255) nombreux qu'ils ne devraient l'être d'après la règle générale; le second cas est dû très vraisemblablement à la désorganisation de quelques noyaux et le

(1) Il faut remarquer que pour faciliter le compte des noyaux j'en ai dessinés le contour au moyen de la chambre claire.

(2) Le nombre inclu dans les parenthèses est placé ici seulement pour compléter le tableau, car malheureusement je n'ai rencontré en réalité aucune oosphère avec un pareil nombre de noyaux.

premier à certaines causes que malheureusement je ne peux pas encore trouver. Quoi qu'il en soit, il est évident que généralement les noyaux d'une oosphère subissent de la bipartition qui se répète huit fois successivement dès le début.

Après la septième bipartition, le cytoplasma manque généralement des grosses granulations indiquées ci-dessus et devient spongieux en apparence et c'est alors pour la première fois après le début de la division nucléaire que j'ai aperçu dans le noyau un nucléole (Pl. XXXII, fig. 12). Après la huitième bipartition, il se forme des cloisons celluloso-siques entre les noyaux ; le cytoplasma devient grossièrement réticulé et enfin le noyau vient à régénérer quelques nucléoles (Pl. XXXII, fig. 13). Du tableau précédent on verra que la division irrégulière s'opère notamment après la septième bipartition.

Les membranes cellulaires formées, les cellules ne tardent pas à se diviser chacune pour son compte. La base de l'oosphère, se conformant maintenant au point végétatif, se développe de plus en plus, de sorte que vers le commencement d'octobre on reconnaît déjà la différenciation des deux cotylédons et vers la fin de ce même mois, quand les fruits déjà mûrs s'apprentent à tomber des arbres, on voit que l'embryon bien développé mesure de 6 à 8 millimètres de long (1).

Au sujet du nombre des oosphères qui se trouvent dans un sac, voici ce que M. STRASBURGER a dit (2) : «Der Embryosack selbst erscheint meist zweikantig und die Corpuscula stehen in 2 oder Mehrzahl auf dieser Kante, an die beiden Seiten der Warze», ce qui confirme mon observation. Outre ce cas, j'ai observé celui où les deux oosphères sont serrées côte à côte, comme chez le *Juniperus* ou le *Pinus* (Pl. XXXI, fig. 4 et

(1) S. Hirase, ぎんなんノ受精期 (*Saison de fécondation du Ginkgo biloba*). Bot. Mag. Vol. VIII, No. 83, 1894, p. 7.

(2) *Die Coniferen und die Gnetaceen*, p. 291.

Pl. XXXII fig. 14). Or, on rencontre généralement dans un nucelle un, deux, ou souvent trois grains de pollen, qui demeurent suspendus aux deux côtés du mamelon nucellaire. J'ai reconnu que, dans un grand nombre de cas, les oosphères d'un sac du *Ginkgo* sont fécondées toutes les deux et cela est dû à ce que chaque oosphère est fécondée par un tube pollinique parce que les deux oosphères sont éloignées l'une de l'autre. Lorsque les deux archégones sont voisines, il n'en est rien, puisqu'une cellule génératrice du tube se divisant en deux cellules-sœurs égales, il est fort vraisemblable qu'alors les deux oosphères d'un sac n'exigent qu'un seul tube pour être fécondées(1). On remarquera que, quoique la fécondation des deux oosphères s'accomplisse, l'une d'elles peut se conformer d'habitude en embryon adulte.

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## 5. CONCLUSIONS.

1. L'oosphère du *Ginkgo biloba* aboutit à la maturité vingt semaines après la pollinisation.

2. Peu de temps avant la fécondation, il se forme une cellule du canal. Dès qu'elle est formée, elle se désorganise sur-le-champ et se sépare de la moitié inférieure du «dispirem».

3. La fécondation s'effectue vers le milieu de septembre, du moins dans notre pays.

4. Après la fécondation, le noyau de l'oosphère ne tarde pas à se diviser et se multiplie en général suivant les puissances du nombre 2.

5. Après la huitième bipartition des noyaux dérivés du noyau de l'oosphère, il se forme des cloisons cellulodiques entre les noyaux engendrés. Chaque cellule, ainsi formée, commence à se diviser pour

(1) Consulter Strasburger, *Histolog. Beft. Heft. IV*, 1892, p. 20.



son compte; après quoi la base de l'oosphère formant le point végétatif se développe de plus en plus pour donner naissance à un embryon.

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Il a été déjà énoncé (p. 309) qu'il y a une relation fort intime entre l'apparence de grosses granulations dans l'oosphère et son remplissage de cytoplasma. Ces grosses granulations se comportent à l'égard des divers réactifs colorants de la même façon que les nucléoles: par exemple, dans les préparations portées pendant à peu près une heure dans la solution aqueuse du vert de méthylène, lavées avec de l'alcool absolu, puis traitées avec de l'essence de girofle, et enfin montées au baume, on voit les granulations et les nucléoles se colorer en bleu, tandis qu'au contraire les granulations chromatiques et le cytoplasma ne se colorent jamais; si l'on remplace l'alcool absolu par une solution alcoolique saturée d'éosine, on voit les granulations et les nucléoles se colorer en bleu plus ou moins foncé, et les granulations chromatiques et le cytoplasma en rouge clair (Matériaux fixés avec du liquide de Flemming!) Grâce à ces réactions on reconnaîtra aisément que les granulations en question ne sont ni des grains d'amidon ni ceux d'aleurone mais qu'au contraire elles se rapprochent beaucoup des nucléoles. Leur ressemblance aux nucléoles à l'égard des réactions, leur apparence près du noyau de l'oosphère au premier abord, et notamment le phénomène presque toujours rencontré que quelques-unes d'elles sont en voie de couler hors du noyau, sont en faveur de la supposition qu'elles sont venues du nucléole dans le noyau de l'oosphère.

En outre, on rencontrera dans les cellules formant la paroi de l'archégone une ou rarement deux granulations situées en dehors de chaque noyau, qui se rapprochent le plus souvent très près de l'oosphère, en étant séparées seulement par une cloison de cellulose

(Pl. XXXI, fig. 5, 6, 7; Pl. XXXII, fig. 9). Traitées avec de la fuchsine acide à 0,2 p. 100, elles se colorent en rouge de même que les nucléoles et ainsi se distinguent-elles aisément des grains d'amidon réservés dans les mêmes cellules. On peut observer néanmoins ce phénomène pendant l'espace de temps compris entre le développement complet de l'oosphère et la septième bipartition de son noyau. Or, on observera le fait fort remarquable que les noyaux dans les cellules de la paroi de l'archégone sont pourvues chacune des *deux* nucléoles avant ce temps limité, mais après d'*un* seul. Il me semble donc très vraisemblable que les granulations en dehors des noyaux de la paroi de l'archégone proviennent d'un des deux nucléoles et qu'elles se transportent de là dans l'oosphère à travers des ponctuations pratiquées sur les cloisons cellulotiques.

En somme, les grosses granulations dans l'oosphère sont de deux sortes à l'égard des sources desquelles elles tirent leur origine: 1° celles provenues du noyau de l'oosphère et 2° celles provenues du noyau des cellules de la paroi de l'archégone. Les granulations des deux sources sont tout à fait identiques l'une à l'autre soit en nature, soit en apparence externe; elles sont néanmoins différentes à l'égard du moment de leur existence, car tandis que les granulations de la première sorte disparaissent au moment du développement complet de l'oosphère, celles de la deuxième commencent alors à prendre naissance.

Les deux grosses granulations découvertes par moi dans les cellules polliniques du *Ginkgo* à côté des sphères attractives (1) peuvent être regardées, peut-être, comme identiques à celles dont il est parlé ci-dessus en raison des réactions similaires. Nous avons énoncé que ces deux granulations peuvent être observées même à l'état

(1) S. Hirase, *Bot. Mag.* Vol. VIII, No. 91, p. 259.

frais, donc par analogie nous sommes amenés à admettre que les granulations en question ne sont nullement des substances artificielles engendrées en vertu des agents fixateurs. Nous sommes en outre d'avis que ces granulations sont à l'état demi-liquide, car on les rencontre souvent à l'état coulant.

Le fait que les nucléoles sortent hors du noyau au moment de la caryocinèse a été énoncé par la plupart des savants. Mais que sont les granulations indiquées ci-dessus, qui se montrent même au moment où le noyau est en repos? Sont-elles provenues des nucléoles? Sont-elles constituées entièrement de la substance nucléolaire? Sont-elles identiques au nucléole extranucléaire qui sort hors du noyau au moment de la caryocinèse? Voilà les questions que je me pose à ce sujet. Il est impossible de les discuter ici, parce que leur solution exigera des recherches spéciales plus approfondies. Bornons-nous maintenant à rappeler que les granulations en question sont évidemment des substances rapportées du noyau de l'oosphère ou des cellules de la paroi de l'archégone dans l'oosphère pour la nourrir.

La relation entre les nucléoles et les fines granulations qui se montrent dans l'oosphère après l'évanouissement des grosses granulations est d'une netteté très remarquable : lorsque le cytoplasma de l'oosphère manque de grosses granulations, il devient riche en fines granulations ; pendant que le noyau de l'oosphère va se multipliant par bipartition, les fines granulations disparaissent peu à peu et alors le noyau de l'oosphère vient à régénérer les nucléoles.

En terminant je suis heureux de remercier M. le Prof. J. Matsu-mura, qui m'a permis de travailler dans son laboratoire et dont les précieux conseils ne m'ont jamais fait défaut ; M. le Prof. S. Ikeno,

qui m'a donné dès le début les conseils les plus précieux ; M. le Dr. K. Fujii, qui a mis à ma disposition avec la plus parfaite libéralité différents livres dans sa bibliothèque ; et enfin M. S. Ôkubo, ancien professeur adjoint au Collège des Sciences pour sa bienveillance.

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## EXPLICATION DES PLANCHES.

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### PLANCHE XXXI.

(Fig. 1 à 7.)

- Fig. 1.**—Une jeune oosphère avec ses cellules du col.—Matériaux récoltés vers le milieu de juin ; préparations colorées avec de la fuchsine acide et du vert d'iode ;  $\frac{240}{1}$ .
- Fig. 2.**—Une oosphère plus âgée avec le noyau qui se rapproche de son bord, pourvue de grosses granulations près du noyau et pleine de vacuoles.—Matériaux récoltés vers le milieu de juillet. Préparations colorées avec de la fuchsine acide et du vert d'iode ;  $\frac{150}{1}$ .
- Fig. 3.**—Une oosphère au même stade représentant une portion. On voit des granulations au-dessous du noyau en voie de couler.—Préparations colorées avec du vert de méthylène et de l'éosine ;  $\frac{240}{1}$ .
- Fig. 4.**—Représente les deux oosphères presque mûres. Dans l'un des deux noyaux (droit) la portion vis-à-vis des cellules du col est convexe ; dans l'autre (gauche) cette portion s'est contractée. On voit des granulations auprès des noyaux.—Prép. colorées avec du vert de méthylène et de la fuchsine acide ;  $\frac{150}{1}$ .
- Fig. 5.**—Une phase plus avancée de l'oosphère. Le cytoplasma dépourvu de vacuoles est parsemé de grosses granulations. On les voit en outre dans les cellules formant la paroi de l'archégone.—Matériaux récoltés vers la fin d'août ; prép. colorées avec de l'hématoxyline de Böhmér ;  $\frac{150}{1}$ .
- Fig. 6.**—Représente la base d'une archégone. On voit les granulations dans les cellules de sa paroi très près de l'oosphère. La cloison cellulosique fort épaissie, mais munie des ponctuations. Prép. colorées avec de la fuchsine acide ;  $\frac{240}{1}$ .

**Fig. 7a.**—Formation de la cellule du canal. On ne voit pas de grosses granulations dans le cytoplasma. Prép. colorées avec de l'hématoxyline de Böhlmer ;  $\frac{150}{1}$ .

**Fig. 7b.**—Une portion de la Fig. 7a plus fortement grossie ;  $\frac{240}{1}$ .

## PLANCHE XXXII.

(Fig. 8 à 13.)

**Fig. 8.**—La cellule du canal se désorganisant et se séparant de la moitié inférieure du «dispirem» et le noyau de l'oosphère descendant.—Matériaux récoltés vers le milieu de septembre ; prép. colorées avec de la fuchsine acide ;  $\frac{150}{1}$ .

**Fig. 9.**—L'oosphère au sein de laquelle se voit un fuseau nucléaire. Le cytoplasma est riche en fines granulations. Matériaux récoltés vers le milieu de septembre. Prép. colorées avec du vert de méthylène et de la fuchsine acide ;  $\frac{150}{1}$ .

**Fig. 10.**—Représente un des 16 fuseaux nucléaires formés dans une oosphère.—Matériaux récoltés vers le milieu de septembre ; prép. colorées avec du vert de méthylène et de la fuchsine acide ;  $\frac{530}{1}$ .

**Fig. 11.**—Représente un des huit «dispirems» formés dans une oosphère. Matériaux recueillis vers le milieu de septembre ; prép. colorées avec du vert de méthylène et de la fuchsine acide ;  $\frac{530}{1}$ .

**Fig. 12.**—Représente tous les noyaux contenus dans  $\frac{3}{17}$  de l'épaisseur d'une oosphère (c'est-à-dire égal à 0,076 mm. qui contient 128 noyaux dérivés de la bipartition répétée du noyau de l'oosphère ; le cytoplasma spongieux et le noyau avec un nucléole.—Matériaux récoltés vers le milieu de septembre ; prép. colorées avec du vert de méthylène et de la fuchsine acide ;  $\frac{150}{1}$ .

**Fig. 13.**—Représente tous les noyaux contenus dans  $\frac{3}{27}$  de l'épaisseur d'une oosphère (=0,043 mm.) dans laquelle des cloisons de cellulose ont été déjà formées.—Matériaux recueillis vers le commencement d'octobre. Prép. colorées avec de l'hématoxyline de Böhlmer ;  $\frac{87}{1}$ .

# Description of *Opisthotenthis depressa* n. sp.

By

I. Ijima, *Ph. D., Rigakuhakushi,*

and

S. Ikeda.

With Plate XXXIII.

During May last, a small octopod, apparently belonging to the rare and very peculiarly shaped genus, *Opisthotenthis*, was brought to us by our collector, a Misaki fisherman, who obtained it on the southern side of Okinose,<sup>1)</sup> about sixteen kilometres west of Cape Sunosaki. It had taken one of the hooks, baited with shark-flesh, of a long line for deep-sea fishing, at a depth of about 250 fathoms. This locality is one of those in or about Sagami Bay, that seem to be teeming with zoological novelties. It is a rich Hexactinellid ground, and of the numerous interesting objects which it has recently yielded to us, might here be mentioned a living *Pleurotomaria Beyrichi*, likewise hooked up by a snood of a long line.

The genus *Opisthotenthis* was instituted in 1883 by Verrill<sup>2)</sup> to receive a West Indian species, named *O. Agassizii* by the same author. So far as we can ascertain no second species has since been added to the genus. In proposing then, the name of *O. depressa* for our Okinose specimen, which differs in many important points from Verrill's species, we consider it unlikely that we are adding but an unnecessary synonym to the literature of Cephalopods.

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1) A submarine bank situated about 18 kilometres south of Misaki.

2) "Supplementary Report on the 'Blake,' Cephalopods." *Bull. Mus. Comp. Zool.*, Vol. XI. Also, "Mollusca of the New England Coast." *Trans. Conn. Acad.*, Vol. VI.

Hoyle<sup>1)</sup> seems to have entertained some doubt as to whether *Opisthoteuthis*, together with *Stauroteuthis* Ver., is not identical with *Cirroteuthis* of Eschricht. In our judgment, so far as *Opisthoteuthis* is concerned, its generic distinction may well be considered as valid, preeminently on account of the unusually depressed head and body, which condition, conjointly with the thick and swollen brachial webs, gives to the animal a shape quite exceptional among Cephalopods. Except for the projecting tips of its arms, it may be compared to a plano-convex disc, of which the plane side is the inferior or the anterior and represents the inner surface of the umbrella. The arched superior or posterior surface includes not only the posterior aspect of an ordinary cephalopod body, but also the dorsal and ventral surfaces as well as the outer surface of the umbrella. The head and body are thus flattened antero-posteriorly. This is accompanied, as might naturally occur, by an outspread of these parts laterally and especially along the ventral web, whereby such parts are, so to say, pushed into the umbrella beneath its outer skin. Hence, the lateral portions of the broadened head and body lie directly over the bases of the lateral arms, while the median portion of the body directly overlies the two ventral arms to a considerable extent. At the same time the siphon and the branchial aperture are shifted over to a considerable distance on the outer surface of the median ventral web, and are directed in the ventral, not in anterior direction as is usually the case. The close and wide connection thus established between the head and body on the one hand and the umbrella on the other, accounts for the fact that the latter, with arms enclosed in it, is horizontally expanded, the former acting as a restraint against its closing.

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1) Challenger Report. Vol. XVI. p. 230.



Apparently the same state of things in *O. Agassizii*, as put down above, is described by Verrill in a different way. According to him, the depressed body is together with the head "closely united" or "wholly adnate to the web connecting the arms, except at the posterior end behind the fins, where it is slightly free and overhangs a little." Again, it is said that the head and body are so closely adnate to the branchial membranes "as to entirely conceal the ventral portions." The position of the siphon and branchial aperture is pointed out by Verrill as being remarkably "posterior." The terms used by him are misleading in so far as they lead one to think that the body had laid itself down in such a way as to have come into union with the webs by its ventral surface, and that the siphon and the branchial aperture had shifted their positions along the ventral surface of the body towards its posterior end. Such is, in our opinion, decidedly not the case. The ventral portion of the body is nowhere to be considered as being concealed, except perhaps the mantle-rim, which is reflected inwards at the branchial aperture (*a*, fig. 9). On the contrary, it stands, at least for the greater part, exposed more than ever, only with this peculiarity, that it forms a part of the general superior surface, thereby losing all definable boundaries from the real dorsal region or from the outer surface of the umbrella. Nor is there any ground for supposing that the siphon and the branchial aperture have any way approached the original posterior end, which is, strictly speaking, to be sought somewhere near the middle of the upper surface of the flattened body, behind the position of the dorsal cartilage. While thus retaining their usual relative position to the posterior body-end, they have shifted themselves a remarkable distance away from the centre, and along the outer surface, of the umbrella.

To go on with the description of our specimen of *O. depressa* the entire superior surface (fig. 2) is covered with a wrinkled and flabby

skin, the wrinkles abounding most near its margins where they generally run, with interruptions, in circular curves. Many of these were probably to be seen even in the living state when the arms were at rest, certainly to disappear, however, under the tension caused by certain movements of the latter. Others may be the result of contraction brought about by immersion in alcohol. Underlying the skin there is a thick layer of very soft connective-tissue, that fills up the webs and also covers the outer aspect of the arms; so that, while it gives such a thickened or swollen appearance to the former, it conceals the latter beneath it, making their course untraceable on the outer side of the umbrella. The same condition should also obtain in *O. Agassizii*.

As already mentioned, the entire superior surface is gently convex, but its central portion, *i.e.*, the head and body proper, in our alcoholic specimen must be described as being rather flattened, except in the region of the eyes, where, it somewhat heaves up into rounded prominences presenting the most projecting points of the upper surface (fig. 1). Otherwise, the head is as low, and about as large and as broad, as the body. The latter does not overhang in any degree the branchial aperture, a condition suggesting that the depression of the body in the present species is carried somewhat to a greater extent than in *O. Agassizii*.

The eyes, which should be very large in *O. Agassizii*, are here of moderate size, and are separated from each other by a wide interorbital space. Their external openings are small semilunar slits, disposed longitudinally and with membranous upper and thick lower lids. The distance between the two openings exceeds twice the diameter of the eye-bulb, but is about equal to their distance from the free edge of the dorsal web.

The fins are very small compared with those of *O. Agassizii*. In

our specimen the left fin is shrunk and smaller than the other, evidently owing to careless handling when fresh. The right fin is well preserved, rather thick and triangular in shape, being about one and a half times as broad (transversely) as it is long. The free apex is rounded and of the two edges, the anterior is somewhat more arched than the posterior. The shape, however, is likely subject to changes, according to the different state of contraction of the internal tissues, as the fins are very soft structures containing no supporting elements whatever. Nevertheless, on raising them from their natural, laterally directed position and then releasing them, they return to the original position of their own accord. The place of their attachment is close behind the eye-bulbs, the distance between the middle of the fin-base and the eye-opening being about one fifth of the distance of the former from the branchial aperture. Moreover, the fin-base is situated more to the middle than the eye-opening, while the fin itself extends laterally but a short distance beyond the same.

The branchial aperture is a small crescent-shaped opening, situated at a distance from the free edge of the dorsal web about four times as great as that from the ventral web. It partially embraces the siphon, which, so far as it shows itself outside the branchial aperture, is of very insignificant size. No part of it can be said to be freely projecting beyond the surface of the ventral web and its presence is only revealed by a slight prominence and by the existence of a small, transversely slit-like siphonal opening close behind the branchial aperture.

As already mentioned, the inner or inferior surface of the umbrella (fig. 3) is plane. The arms do not project above it, except very near the tips, where the webs becoming thinner and fold-like, join them on their upper sides. The skin is tolerably firmly attached to the inner surface of the arms, as a result of the fact that there is interposed on

this side little or no soft connective-tissue, so richly developed within the webs as well as over the outer surface of the arms. The entire skin is on the whole smooth, at any rate by no means so flabby as on the outer side of the umbrella. This difference in the amount of skin on the two surfaces is assuredly a provision, by which the animal is readily enabled by special exertions of its muscles, to assume a shape concave on the lower side, as, for instance, when it would attach itself by means of suckers to a projecting substratum or when it would exercise swimming motion by alternate closure and expansion of its arms. We believe the kind of locomotion just mentioned is of much greater moment to *Opisthotenthis* than to most other Cephalopods, since the ejection of water from the comparatively small branchial chamber and siphon can not but be of subordinate significance.

The mouth is situated somewhat eccentrically, *i.e.*, a short distance nearer to the free edge of the dorsal web than to that of the ventral. Its position about corresponds, on the superior aspect of the animal, to the middle of a line connecting the anterior ends of the fins. There is a finely verrucated buccal membrane present in the mouth. The jaws show no characteristic features that seem to be worth noticing (figs. 4 & 5). We have sought in vain for the radula, but will not positively assert its total absence.

The arms are subequal. The longest is the second lateral arm, after which the ventral, the first lateral and the dorsal arms are successively shorter in the order mentioned. As seen after denuding them of skin, they are rather stout and are thickest at the base, where they come in contact with one another and whence they gradually taper off towards the tips. According to Verrill, the arms of *O. Agassizii* are much narrowed towards the bases and these are said to be not in contact,—a description presumably based solely on their external appearance on the inferior side, where the suckers decrease in

size and the zone between the two rows of cirri lessen in breadth towards the base of the arms. The free ends are rather slender, are compressed, and more or less outwardly curled. By far the greater extent, say about nine tenths of the entire length of arms, is plainly webbed, and such portions show a remarkable curvature on the same plane, *viz.*, both right and left arms are all more or less curved dorsad, so that while the two dorsal arms face each other with their concavity, the two ventral arms do so with their convexity so that their ends are turned laterad away from each other (fig. 3). None of the arms shows any sign of hectocotyization.

Consequent upon the horizontal curvature of the arms, the edge-line of the dorsal web is the least extensive of all, since the two dorsal arms approach each other towards their ends. Moreover, it is deeply slackened in, giving rise to a median angular notch, the two sides of which are symmetrical. On the other hand, the ventral web has, as is easily comprehensible, the most extensive edge-line, which is almost straightly stretched. With respect to the lateral webs, their edge-lines are all of about the same extent, always with this peculiarity, that every one of them is obliquely indented, so as to form an open angle, the apex of which lies at least four times more distant from the tip of the next dorsal arm than from that of the next ventral. As the result of this fact, a lateral web can not be divided by any line into two symmetrical parts and each lateral arm, as also the ventral arm, has a greater stretch of narrowed web-continuation along the ventral than along the dorsal side near its end. There is then an appearance as if the two ends of the free edge of a lateral web terminated at unequal distances from the tips of the arms connected by it, as is known to be the case in some Cephalopod species. But such seems not to be the real state in *O. depressa*. We are rather inclined to consider that the above described condition of lateral webs is merely

dependent upon the peculiar horizontal curvature of the arms bearing them, and that their shape would be similar to that of the dorsal or of the ventral web, should the bounding arms dispose themselves respectively like the dorsal or the ventral arms, what is likely to happen not unfrequently during life.

The suckers and cirri show an arrangement as in *O. Agassizii*. The former, arranged in a single row to each arm, number 42-52 as far as can be counted, the greatest number being found on the ventral arms. They are on the whole very small. Along the greater part of the arms, they are of about the same size, but do gradually though slightly decrease in size both proximally and distally, becoming especially smaller towards the tips of the arms. Unlike *O. Agassizii*, those situated about halfway along the arms are not any smaller than those which precede or follow them. The suckers have simple hollows, their edges being generally but little prominent above the surface of the skin.

The cirri, present in two rows on each arm and alternating with its suckers are very inconspicuous structures, being small, slender and attenuated to a point. Those towards the tip and also those close to the base of the arms are especially insignificant, being reduced to mere minute prominences. They commence proximally between the first and the second suckers. The space enclosed between the two rows of cirri is broadest halfway along the arm and narrows towards either end of it.

The colour, as observed on the second day after the specimen had been put into weak alcohol, was predominantly madder-red. On the superior surface, the head and body were somewhat uniformly of that colour, but very dull in tone, except in the region just above the eyes and the under surface of the fins, where they were poor or altogether wanting in pigment. On the periphery of the superior surface the

chromatophores were arranged in streaks that generally ran with interruptions, in circular paths. On the inferior surface, the red was principally confined to the interbrachial spaces, the greater part of the arms themselves as well as the cirri and suckers being of light colour.

The measurements of our specimen are as follows :

Median diameter of the entire animal, 55 mm.

Transverse diameter across fins, 65 mm.

Thickness at the middle of head, about 8 mm.

Length of body and head, from the branchial aperture to the level of the anterior borders of eyes, 27 mm.

Breadth of body proper, about 23 mm.

Breadth of head across eyes, 26 mm.

Between eye-openings, 22 mm.

Diameter of eye-bulb, 9 mm.

Between fin-bases, 17 mm.

From base of fin to its tip, 5 mm.

Thickness of arm near base,  $6\frac{1}{2}$  mm.

Length of dorsal arm, 38 mm.

Length of 1st lateral arm, 44 mm.

Length of 2nd lateral arm, 48 mm.

Length of ventral arm, 46 mm.

Length of dorsal web from mouth, 23 mm.

Length of ventral web from mouth, 27 mm.

Breadth of lateral web from mouth,  $25-27\frac{1}{2}$  mm.

Diameter of largest sucker, 1 mm.

Length of longest cirrus,  $1\frac{1}{4}$  mm.

Of the internal anatomy we can offer only such scanty notes as could be taken after a few incisions made so as to least impair our unique specimen.

The presence of a dorsal cartilage could only be ascertained after partially removing the dorsal skin. It is a single, transversely situated, cartilaginous bar (*c.*, fig. 6), no part of which is directly continued into the fins. Here is another important point of difference from *O. Agassizii*, in which it should occur in two separate pieces, each contained in the fin itself. The simple cartilaginous bar of the present species, is thin, 1 mm. broad (antero-posteriorly), 9 mm. and 11 mm. long respectively along the anterior and the posterior edge. It is situated about 4 mm. behind the level of fins, beneath the thick skin and closely over the visceral sac above the posterior part of the liver (*d.c.*, fig. 9). From its either end a muscle takes its origin (*m.*, fig. 6). The latter soon bends forwards and inserts itself at the fin-base of the respective side.

Cutting open the mantle-cavity, the siphon, of which but a small portion was visible from outside, is exposed in its entire length (fig. 7). It then measures 7 mm. in length and about as much in breadth at the base, representing a much flattened cone in its general shape. Its lower wall, which corresponds to the dorsal aspect of the siphon of normally shaped Cephalopods, is completely aduate with the connective tissue of the ventral web. Its muscular substance splits, just beneath the anus, into two bands, which after running antero-laterally beneath the branchial chambers, finally become lost in the connective tissues. The upper wall of the siphon is covered by the chromatophore-bearing skin directly continuous with that of the outer surface of the umbrella and is reflected outwards along its free edge at the siphon-basis, especially so at two lateral positions which evidently serve as the so-called button (*but.*, figs. 7-9).

The mantle-edge at the branchial aperture is reflected inwards (*a*). The reflected edge is laterally continued into a fold (*b*), which incompletely shuts off the branchial chambers on the median side and



whose edge is capable of being clasped by the above mentioned button of the corresponding side.

It is convenient for description's sake to speak of two branchial chambers, each containing a gill and which communicate with each other, provided the buttons are fixed, by only a narrow space at the inner end of the siphon. From this connecting space the two branchial chambers extend divergently forwards and laterally for a distance of about 11 mm. They overlie the connective tissue of the umbrella, clasp from behind the visceral mass and are superiorly covered by the mantle (*man.*, fig. 7) which strictly speaking represents their ventral wall. On the floor of the connecting space and right at the inner end of the siphon, there is a medianly situated, rounded elevation, bearing the anus, discernible as a blackish spot (*an.*, fig. 7). The said elevation is posteriorly closely embraced by a thin fold, likewise of the floor, and is superiorly directly continuous with the median septum (*sep.*) that divides the entrances into the two branchial chambers.

Each of the latter is widest near the siphon-base and narrows antero-laterally to a cleft-like terminal portion. The widest portion is occupied by an extremely shortened gill (*gi.*), which is attached to the membranous anterior wall enclosing the visceral mass (*v.w.*). Thus the gill is directed backwards or ventrad. Around its short rachis are grouped together the lobular lamellae, so that the entire organ is reniform and presents an appearance not unlike that of half of a peeled orange. There are in all six lamellae to each gill, but the one most medianly situated is very rudimentary and can not be observed when seen from above.

It was of course very desirable to determine the sex of our specimen. Although there was no sign of hectocotylization on any of the arms, we discovered immediately on opening the mantle-cavity,

an organ which could not but be taken for the penis. In fact, further dissection soon verified the view that we had before us a young male. It is to be assumed that the hectocotylization had not yet commenced in our specimen.

The penis (*p.e.*) is a tube-like body about 3 mm. long, arising from the anterior wall of the left branchial chamber, about midway between the anus and the gill. It is directed backwards towards the inner end of the siphon. Within the visceral sac, the penis-root is directly continuous with a swollen ovate body (*sp.s.*, figs. 8 & 9), which looked as if consisting of a coiled tube, apparently owing to the presence of spirally arranged folds within. We identify this body as the spermatophore-sac. This is joined at its anterior end by another ovate body (*pr.*) of about the same size, situated on the left of the cœcum. This is probably the prostata. It is a thin-walled sac that contained a whitish mass, which, on close examination, proved to consist of certain epithelial duplicatures. From the junction between the prostata and the spermatophore-sac, a rather thick and spindle-shaped duct (*s. r.*), which proceeds towards the right, eventually to continue itself into the thin vas deference. The swollen part of the spindle-shaped duct exactly corresponds in position to the seminal vesicle of other cephalopods. The vas deferens (*v. d.*) runs at first towards the left and then sharply turns on itself to pursue an opposite course, thus forming a loop that seems to be connected with the spermatophore-sac by a filamentous band. The organ, which is to be considered as the testis (*tes.*), consists of three elongated lobes or rami. The first and the longest runs obliquely forwards and towards the left, crossing over the seminal vesicle and the prostata; the second runs forwards over the cœcum and the third, which is the shortest, pursues a downward course behind the cœcum. The rami have a thin membranous envelope, the capsule, and contain a minutely verrugated

mass. The latter, on microscopic examination, was found to consist of a complicated system of epithelial duplicatures, the cells of which were cylindrical or spindle-shaped and regularly arranged. These are probably to be considered as spermatoblasts. Nowhere is the spermatozoon to be found, indicating that our specimen stands in a very young stage of sexual development.

Of other anatomical facts, incidentally observed during the dissection of the genital parts, we find no points of particular interest and therefore prefer to leave them here unnoticed, only referring the reader to what are embodied in our fig. 9, Pl. XXXIII.

*College of Science, Imperial University, Tokyo,*

*June 10th 1895.*



**Explanation of Plate XXXIII.***Opisthotenthis depressa* Ij. & Ik.

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- FIG. 1. Side-view. Nat. size.
- FIG. 2. Superior view. Nat. size.
- FIG. 3. Inferior view. Nat. size.
- FIG. 4. Ventral jaw.  $3\times$ .
- FIG. 5. Dorsal jaw.  $3\times$ .
- FIG. 6. Dorsal cartilage and its muscles exposed.  $2\times$ .  
*c*, Cartilage.  
*m*, Muscle.  
*f*, Fin.
- FIG. 7. Mantle-cavity exposed by incisions on either side of the branchial aperture and mantle thrown forwards so as to show its inner surface. About  $2\times$ .  
*a*, Reflected rim of the branchial opening.  
*an.*, Anus.  
*b*, Continuation of *a*, capable of being clasped by the button *but*.  
*br. h.*, Branchial heart peering through the visceral wall.  
*but.*, Button.  
*gi.*, Gill.  
*man.*, Inner surface of mantle.  
*pe.*, Penis.  
*sep.*, Septum of the mantle-cavity.  
*si.*, Siphon.  
*si. o.*, Opening of siphon.
- FIG. 8. Reproductive organs, diagrammatically represented.  
*an.*, Anus.  
*pe.*, Penis.  
*pr.*, Prostata.  
*sp. s.*, Spermatophore-sac.  
*s. v.*, Seminal vesicle.  
*tes.*, Testis.
- FIG. 9. Half-imaginary median section.

*a. b.*, Arm-base.

*br. o.*, Branchial opening.

*buc. b.*, Buccal body.

*c. g.*, Cerebral ganglion.

*ca.*, Cæcum.

*d. c.*, Dorsal cartilage.

*e. b.*, Eye-bulb, right.

*in.*, Intestine.

*l.*, Liver, right lobe.

*op. g.*, Optic ganglion, right.

*p. g.*, Pedal ganglion.

*st.*, Stomach.

Other letterings as in foregoing figures. Dotted line indicates the upper surface of arms.





# On the so-called Excretory Organ of Fresh-water Polyzoa.

By

Asajiro Oka, Ph. D.

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*With Plates XXXIV-XXXV.*

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Since VERWORN discovered in 1887 a peculiar structure in the body of Phylactolematous Polyzoa, to which he vaguely assigned the nature of a nephridium, there have appeared no less than half a dozen papers, each dealing more or less minutely with this supposed organ of excretion. The accounts given by the authors in regard to its anatomy as well as to its morphological value, are, however, far from being coincident. On certain important points in the structure, the statements are even directly opposite. While one author insists on its excretory nature and goes so far as to homologize it with the nephridia of other animals, there are others who wholly deny its excretory function, or even its very existence. Such being the case, it needs no insistence that a renewed investigation on the subject was very much to be desired.

In the course of last autumn I preserved a large number of colonies of *Pectinatella*, which are found in abundance in a large pond in the University-grounds here, and made them the object of study, wishing to decide, if possible, in how far the different statements of former investigators were justified. In the following pages I give an account of my results, and offer a few theoretical considerations as to the morphological value of the organ in question.

The main points in the structure of this organ were described by me in No. 76 of the *Zoological Magazine* Vol. VII (1895), but as I have since studied various allied animals as to their excretory organs and have come to conclusions that seem to elucidate the nature of this so-called excretory organ of Polyzoa satisfactorily, I think it will be of service to publish them here, in a journal that enjoys a wider circulation than the one above mentioned. My conclusions on the subject are totally different from those arrived at by CORI (1893), which, owing, no doubt, to their having been quoted by KORSCHÉLT and HEIDER in their *Lehrbuch*, seem at present to be the most widely accepted.\*

*Material and Methods.* The colonies were first stupefied with a fluid prepared after the recipe of Dr. CORI (10% solution of methyl alcohol in 0.75% salt solution, with a few drops of chloroform) and then fixed with Flemming's fluid. They were then washed in running water and hardened gradually in alcohol. For staining, I used Behner's hamatoxylin, sometimes in connection with alcoholic solution of eosin. The stupefying fluid of the Prague naturalist seems to work especially well upon such forms as Polyzoa, for I was able by its help to preserve the colonies with every polypide fully protruded. As noticed above, all the material I used for my study was of one species, namely *Pectinatella gelatinosa* OKA.

In order to compare the organ to be treated below with the nephridia of allied groups, I have studied two other forms somewhat in detail. They were *Barentsia misakiensis* OKA and *Phoronis Kavalerskii* CALDWELL. The former was collected by me in large numbers at Misaki last summer; the colonies that were found upon empty tubes

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\* For instance Vangel (1894), who published recently a rather popular account of the Fresh-water Polyzoa of Hungary, states:—"Legújabb időben C. J. Cori a Cristatella nemnél Kiválaszt's vizedényeket talált, a mi a mohállatoknak a férgekhez való közel rokonságára vall."



of sedentary annelides and upon the stems of hydroids, were carefully removed from the substratum and then fixed with saturated solution of corrosive sublimate in sea-water, used hot. Although some authors have stated that it is impossible to study the nephridia of Endoproctous Polyzoa by means of sections, I find it not only possible but also necessary in investigating their minute structure. My sections,  $5\mu$  in thickness, show the structure of the nephridial tubes pretty well, and by reconstruction, the entire figure of the organ can be obtained without much difficulty.

For the specimens of *Phoronis Kowalevskii* CALDWELL I am indebted to Dr. CORI, who kindly sent them to me together with specimens of some other forms. They had been fixed with chromo-acetic acid and were really in a state of excellent preservation, as judged from the appearance of sections.

### Historical Account.

VERWORN (1887) who was the first to give any account of this organ in Phylactolomatous Polyzoa, states that there are two ciliated tubes, situated on the anal side of the œsophagus directly beneath the external layer of the integument. He describes them as follows: "Die beiden Kanälchen, die eigentlich ihrer Kürze wegen kaum diesen Namen verdienen, werden von einer einzigen Lage kubischer Mesodermzellen gebildet, welche mit Wimpern besetzt sind. An der inneren Öffnung setzen sie sich unmittelbar in das Mesodermepithel der Leibeshöhle fort, aussen grenzen sie an das Ektoderm des Lophophors. Beide Kanälchen vereinigen sich kurz vor ihrer äusseren Mündung zu einem einzigen." He thus left the endings of the tubes undetermined, confining his attention to the median portion where they are most conspicuous. After making the above remark, he

suggests the homology of this organ with the segmental organs of worms, especially with those of Endoproctous Polyzoa.

KRAEPELIN (1887), who nearly at the same time with VERWORN published a monograph of German Fresh-water Polyzoa mentions a glandular body situated above the base of the epistome, but he wholly denies its excretory nature, saying that, "an irgend welche Beziehung zu den Exkretionsorganen der *Pedicellina* oder gar der Würmer ist wohl um so weniger zu denken, als bei den übrigen Süßwasser-bryozoen ähnliche Bildungen völlig vermisst werden."

The account of this organ given by BRAEM (1890) is very different from the preceding ones. He observed the ciliated tubes mentioned by VERWORN, but he attributes to them work of quite a different nature. To quote his own words:—"Das ganze Gebilde ist nichts anders als eine Fortsetzung der Lophophorhöhle, welche eben so wie sie in Form des Ringcanales den Pharynx umgreift, auch das Epistom zu umgehen genöthigt ist, um auf diese Weise zu den anal über dem Munddeckel befindlichen Tentakel Zutritt zu erhalten." Thus it is clear that this author regards the short tubes as a sort of connecting canal between the right and left halves of the lophophoral cavity, whereas the space left between them is looked upon as the passage to the epistomal cavity. Moreover, a certain number of tentacles situated near the middle point of the inner margin of the lophophore open into the cavity of these short tubes and are in this way brought into connection with the lophophoral cavity like all the rest of tentacles. BRAEM also denies the existence of an opening by which the cavity communicates with the exterior.

In a paper on *Pectinatella gelatinosa* (1890) I gave a short description of this funnel-like structure. The conclusions published therein are, though of course independently arrived at, exactly the same as those of the preceding author, except as to the external opening.

Regarding that I made the following remarks :—"There should be some orifice by which they open outwards, for the high degree of development they attain prove that they are not useless remnants. This makes me venture to assume the existence of minute pores, at least on the two or three innermost tentacles of the anal side, presumably at their tips, although I am unable to produce any positive proof."

According to CORI (1890), the body-cavity of Polyzoa is divided by an incompletely developed diaphragm into two portions, the lophophoral cavity and the body-cavity s. str., which correspond to the 'Prosomhöhle' and 'Metasomhöhle' of *Phoronis* respectively. The nephridium consists of two short ciliated tubes which open into a median unpaired bladder-like sac, that communicates in its turn with the exterior. "Die unteren Enden der beiden Kanäle, der Nierenkanäle, münden mit weiten Öffnungen, den Nephrostomen, zu beiden Seiten des Ganglions in die Leibes (Metasom-) höhle ein." The lumina of the median tentacles are prolongations of the lophophoral cavity, being connected with the latter by a sort of narrow channel running beside the nephridial tubes. Such tentacles situated above the nephridium are five in number (3. 2. 1. 2. 3.); of these the three median ones stand in no connection whatever with the latter organ, while the remaining two communicate with it by means of the "Nebentrichter." The author remarks further, that the epistomal cavity open on both sides in the lophophoral cavity, contrary to the statement of BRAEM.

If we compare the above statements, we find that the chief points of disagreement with regard to the structure of the organ are as follows. The cavity inside the ciliated tubes is, according to BRAEM and myself, a continuation of the lophophoral cavity, while CORI regards it as a prolongation of the body cavity s. str., or the "Metasomhöhle," if we adopt his terminology. The lumina of a certain number of

median tentacles open, according to BRAEM and myself, into the cavity of the ciliated tubes, while CORI maintains that they communicate with the lophophoral cavity by means of a canal outside the tubes. CORI found an unpaired median bladder which neither BRAEM nor I was able to discover. Lastly, CORI observed without difficulty the external opening of the organ, which I confessed I could not find, although I thought its existence most probable, while BRAEM states positively that there exists no such opening in reality.

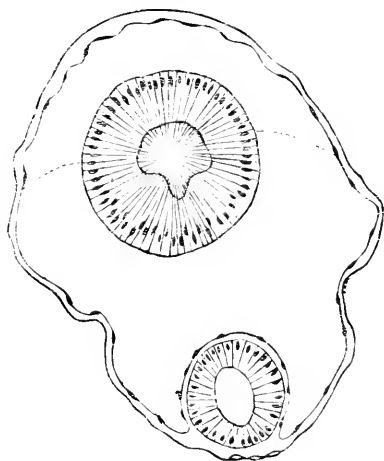
### My Own Observations.

*Position.* In order to understand the real position which the nephridium occupies in a polypide, it is necessary to know exactly the form and extension of the body-cavity. I will give here, therefore, a short account of the organisation of a polypide as far as the body-cavity is concerned, before going to the discussion of the subject itself. This will serve at the same time as an explanation of the terms to be employed hereafter.

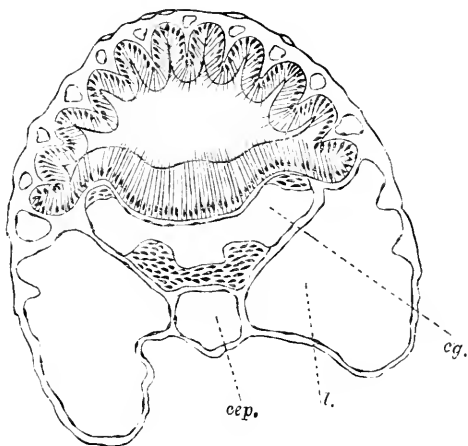
Each polypide has a more or less elongated cylindrical form, at the distal end of which is fixed a horseshoe-shaped lophophore. For the sake of convenience, the animal may be placed in such a manner that the lophophore comes uppermost, with its convex side directed towards the observer and the various portions of the body may be accordingly denominated as upper, lower, right, left, front, back, &c. For the last two may also be used the words oral and anal from the position of these openings. As is well-known, the cavity of the polypide communicates freely at its lower end with the general cavity of the colony, or the cœnoecial cavity of old authors, so that there is only one continuous cavity in each colony. Towards the upper end, the form of the body-cavity becomes somewhat complicated, owing to the

presence of certain organs in this region, and also to the peculiar shape of the body itself.

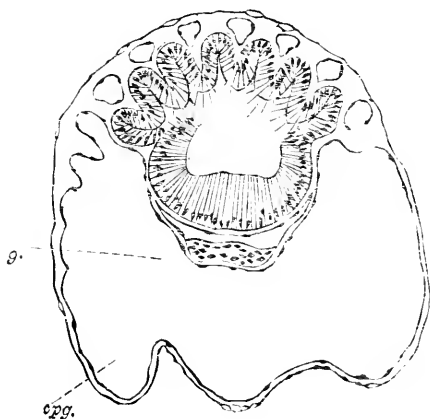
Woodcut 1.



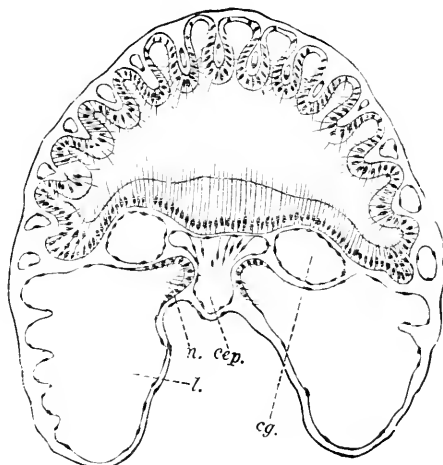
Woodcut 3.



Woodcut 2.



Woodcut 4.



The exact form and extension of the body-cavity at the upper end of the polypide and its relation with various organs will be best understood by referring to the accompanying woodcuts, which show cross sections of the upper portion of a polypide at the levels indicated

by the lines *t1*, *t2*, *t3*, and *t4*. in fig. 1 Pl. XXXIV. Beginning with the lowest of the series, we find in woodcut 1. that the polypidal wall encloses at this level a simple body-cavity in which the œsophagus is seen floating without any connection with the body-wall. In woodcut 2, which represents a cross section at a level a little higher than the last, a portion of the nervous ganglion is seen on the anal side of the œsophagus. The body-cavity is still simple. In the next figure (woodcut 3) we notice beside the ganglion two septa-like folds of the lining epithelium, that connect the ganglion with the body-wall on the anal side, dividing the body-cavity into three different portions. The two lateral spaces, which are continuous on the oral side at a lower level, are portions of the lophophoral cavity, while the median narrow one extends itself upwards into the epistome. In the section represented in woodcut 4, the epistomal cavity is found much larger than in the last figure, with the horn-like prolongations of the ganglionic cavity on both sides. The septa-like folds of the lining epithelium which consisted in the last section of two epithelial layers of equal thickness, are now found to have changed their structure by the considerable thickening of one of the layers that faces directly towards the lophophoral cavity, and, besides, by the growth of cilia on it. This thickened portion of the epithelium represents nothing but the lower end of the tubular structure hitherto supposed to be a nephridium.

By reconstruction from the above and many other sections, we are led to the following conclusions. 1. In the median and lower portions of a polypide the body-cavity is simple. 2. In the upper region this cavity is divided on the anal side into three portions, the median epistomal cavity and two lateral halves of the lophophoral cavity. 3. The ciliated tubes open into the lophophoral cavity. 4. The walls of these tubes are prolongations of the lining epithelium

of the last cavity. It might be remarked here, further, that the lophophoral cavity is separated from the rest of the body-cavity by a sort of diaphragm on the oral side, while on the anal side this boundary is by no means so sharp. The dotted lines in woodcut 1 show the limit of the diaphragm. An anal diaphragm, such as was described by CORI, seems not to exist in this genus.

Thus a renewed investigation convinces me of the correctness of my former statement, as well as that of BRAEM, that the cavity of the ciliated tubes stands in open communication with the lophophoral cavity. I reproduce here those passages that show briefly how I then represented this connection. "The wall of these tubes are continuations of the epithelial lining of the invaginable portion of the endocyst. They open below into the body-cavity by funnel-shaped openings." "The shape of the funnel-like openings may be compared most appropriately with the obliquely cut end of a hollow tube." "As the two tubes deviate from each other below, a part of the perigastric space appears between them. This is the passage by which the cavity of the epistome communicates with the perigastric space" I can not understand why CORI describes the nephrostomes as opening into the 'Metasomhöhle,' for the communication between the lophophoral cavity and the cavities of the ciliated tubes is too obvious to escape attention. However, this difference in our statements might have arisen from the fact that the boundary between the lophophoral cavity and the rest of the body-cavity on the anal side is necessarily arbitrary and we may have fixed on different levels for it.

After having thus determined the form and extension of the body-cavity, we may now proceed to the discussion of the position which the ciliated tubes occupy in a polypide. This can best be done by referring to fig. 1 Pl. XXXIV, a schematic drawing which has been deduced from a study of cross and longitudinal sections. It repre-

sents the upper portion of a polypide cut longitudinally at the median line and serves to illustrate the relations between the various cavities in that region, otherwise very difficult to understand. On the anal side of the œsophagus we can distinguish four sorts of cavities, namely, the perigastric cavity (*epg.*), the ganglionic cavity (*cg.*), the epistomal cavity (*cep.*) and the cavity of the median tentacle. Of these, the ganglionic cavity stands in no connection whatever with the rest of the body-cavity. The epistomal cavity is directly continuous with the perigastric, as indicated by an arrow in the figure; the cavity of the tentacle also communicates with the latter, but only indirectly by means of a wide cavity, the lophophoral cavity, that lies behind the septum-like fold of the lining epithelium marked *plep.* in the figure. This connection is also indicated by an arrow. The partitions (*plep.*), of which there is one on each side of the median line, meet at the upper end, and thus separate the epistomal cavity completely from the lophophoral. Sections show that the wall consists of two layers of epithelium of different thickness, both directly continuous with the lining epithelium of the body-cavity; it is the thicker layer, facing laterally, that has been regarded as the lower portion of the supposed nephridium.

In fig. 4, Pl. XXXIV representing a cross section executed at the level marked 4 in the diagrammatic figure (fig. 1. Pl. XXXIV), we find that the short ciliated tubes are closely enveloped on the anal side by the outer (ectodermal) layer of the body-wall, and on the oral side by the lining (mesodermal) epithelium of the epistomal cavity. In other words, the tubes can be regarded as lying between the two layers of epithelium that constitute the body-wall. This was pointed out by CORI, who writes: "In die Leibeswand ist die Niere in so fern eingelagert, als sie zwischen der Peritonealschicht und der Epithelschicht, also retroperitoneal zu liegen kommt." BRAEM's account of the position



of these tubes is exactly the same, although the word 'retroperitoneal' can not be used here, for the author regards the cavity inside the ciliated tubes as a part of the peritoneum itself. On this latter point I am of the same opinion with BRAEM, from reasons to be given afterwards. At any rate, the statements of all the writers agree as to the actual position of the organ, which may be summed up as follows. In *Phylactolæmatous* Polyzoa, there are two extremely short ciliated tubes situated on the anal side of the body, between the anus and the base of the median tentacles of the inner row, bounded on the anal side by the ectodermal and on the oral side by the mesodermal layer of the body-wall. The walls of these tubes are directly continuous with the lining epithelium of the body-cavity.

With regard to the lower end of these tubes the existing accounts are not so harmonious. CORI, who names the boundary between the thickened and ciliated part of the lining epithelium of the body-cavity, which, by-the-by, constitutes the so-called nephridium, and the ordinary thin portions of the same layer, as the Nephrostome, states that it opens into the "Metasomhöhle," or the lower division of the body-cavity. I, on the other hand, mentioned in my former paper that it opens into the lophophoral cavity. Renewed investigation enables me to maintain the correctness of my former statements, as may most easily be understood from the figures. Woodcut 4 shows decidedly that, contrary to CORI's account, the ciliated tubes at the lower end open into the lophophoral cavity.

*Form and Structure.* In describing the form and structure of the ciliated tubes I have thought it best (1) to figure and describe the actual sections which are rather small in number, and (2) to illustrate the relations of these tubes with other portions of the body by means of diagrammatic figures. To those who are not themselves occupied in studying the subject, schematic representations of a highly diagram-

matic nature are, it appears to me, of great service.

Figs. 2-8, Pls. XXXIV-XXXV, represent cross sections of the ciliated tubes with the neighbouring parts of the polypidal body. Beginning with the lowest of the series, we find in fig. 2 that the tubes communicate laterally with the cavity of the 3rd tentacle (counted from the median line, the median tentacle being No. 0), together with which it opens into the lophophoral cavity. In fig. 3, the tubes are already closed, but their wall is not of equal thickness everywhere, the part further removed from the median line of the animal being nearly as thin as the lining epithelium of the body-cavity. The inequality in the thickness of the wall disappears in the few following sections, not figured here, in which the lateral portion is just as thick as the median. In the next figure (fig. 4) the lumina of the 2nd tentacles of both sides, which open below into the cavity of the ciliated tubes, are seen already separated from the latter. It is one of the places where the cavity of the second tentacle opens into that of the tubes that CORI figures and describes under the name of "Nebentrichter." In the same figure, we find that the two tubes have their median walls already in contact, and in fig. 5 they are united into a single tube, with the lumina of the second tentacles on both sides. This single tube stands, further, in communication with exterior by means of a small pore (*p.*). The next figure (fig. 6) represents the tube on the point of being divided again into three small tubes, which are nothing other than the lining epithelium of the tentacular lumina, as may be seen from figs. 7 and 8. The only difference between these and the lining membrane of other tentacles is that the former have decidedly more nuclei in a section than the latter. Thus in the individual represented by this series of sections, the ciliated tubes (which hardly deserve this name on account of their shortness) are continuous with three median tentacles at the upper end, and a little below and laterally with the tentacles No. 2, by means of

what CORI calls 'Nebentrichter.' Fig. 1, Pl. XXXIV was made from another such individual.

In figs. 9-13 we have another series of cross sections. The individual from which these sections were got differs from the last one only in so far, as the number of tentacles that open into the ciliated tubes is four instead of five. In fig. 9, which is comparable to fig. 3 of the last series, we see the tubes as two oval sections lying side by side; here they are very conspicuous, and it was undoubtedly this portion which first drew the attention of VERWORN. It is also evident from the figure, that everybody looking at such a section for the first time would take it for a tube of some length and be inclined to compare it with some tubular organs of other animals, although a reconstruction of the whole series will show immediately that in reality these tubes are not half so long as wide. In fig. 10, the tubes are already in contact with each other, and the lumina of the tentacles No. 2 (2, 2.) can vaguely be distinguished from the cavity of the tubes proper; the boundary between them being the "Nebentrichter" of CORI. The figure 11 corresponds to fig. 5 of the last series and shows how the tubes unite into a single tube, while the lumina of the tentacles No. 2 becomes separated from the cavity of the now single tube. Also, the minute pore (*p.*) brings the latter cavity in connection with the exterior. Fig. 12 is like the preceding one in every respect except that the single tube is here not connected with the external layer of the body-wall. In fig. 13 the single tube is again divided into two small tubes,—the lining epithelium of the tentacles No. 1. In this case we have no unpaired median tentacle.

In figs. 14 and 15 I have endeavoured to show diagrammatically the position and topographic relations of the so-called nephridium of the animal. The ectodermal layer is represented by bold lines, and the mesodermal layer by fine lines everywhere, except at those places

where the latter is thickened and ciliated. Where such modification takes place is indicated by thickening of the line and by putting fine oblique lines on it. The arrows show the communications between various cavities in the neighbourhood of the organ.

As stated above, my researches lead me to conclude that the statements in my former paper with regard to the connection of the median tentacles with the ciliated tubes are correct. In his second paper, CORI criticises my observations on this point in the following words; "Es dürfte auch in diesem Falle ein Untersuchungsfehler, was die Verbindung des genannten Organs mit den Tentakeln betrifft, vorliegen, wie auch in Bezug auf das Fehlen der äusseren Öffnung." I am ready to acknowledge the correctness of this remark as far as concerns the presence of the external opening, but as to the first part it is difficult for me to accept its validity. The figures in CORI's own paper, especially the figures 6-10, can not be interpreted as showing the continuity of the tentacular lumina with the lophophoral cavity outside the ciliated tubes. It is however no easy task to observe the true bearings of these cavities, for in the majority of individuals, the floating cells or the leucocytes, of which I shall speak afterwards, are accumulated in masses at the base of the tentacles, making the communication of the latter with the ciliated tubes extremely obscure. And it was no doubt this circumstance that caused the difference in our statements.

As to the histological structure of these tubes I have nothing new to add. In the paper referred to above, CORI describes and figures the cells that constitute various parts of the organ: "Von dem Leibesepithel hebt sich das Trichterepithel deutlich durch die Helligkeit seines Plasmas ab. An der freien Fläche zeigen ferner die mit langen Wimperhaaren versehenen Trichterzellen einen äusserst scharfen Kontour, der entsprechend die einzelnen Zellen kleinen Unterbrechun-

gen besitzt." He remarks further that the ciliated canals are composed of cubical cells with round nuclei. As regards his "unpaarer Ausführungsgang" he observes that the constituent cells, which have no cilia, are flattened when the cavity is filled up with excretory cells, but are more or less cubical when it is empty. I have found too in all my sections, that a little above the point of union of the two tubes the wall ceases to be ciliated. The non-ciliated portion of the single tube is certainly what CORI calls the "Ausführungsgang," but, as might be seen from the diagrammatic figures of the entire structure, this name is little applicable, at least in the case of *Pectinatella*. Indeed I have many longitudinal sections of polypides that look exactly like the fig. 14 of CORI, but in all of them the portion corresponding to CORI's "Ausführungsgang" proved to be nothing but a part of the body-cavity. An important character that ought not to be omitted in the description of the supposed nephridium of fresh-water Polyzoa is that none of the constituent cells bear a glandular appearance.

*Function.* The fact that the ciliated tubes open on one hand into the body-cavity by ciliated funnels and communicate on the other with the exterior through a small pore in the body-wall, naturally reminds us of the segmental organs of certain groups of animals. But what is the real function of this organ?

The so-called nephridium of Phylactolæmatous Polyzoa resembles the typical segmental organ, in so far as it represents a passage through which the body-cavity communicates with the exterior, but there still exists a great difference. It is destitute of the glandular portion which forms functionally the most important part of an excretory organ. Here the excretory function can not be performed by the ciliated tubes themselves, which can at most serve, by the activity of the cilia, as an organ of deportation of solid matters floating in the perivisceral fluid.

For marine Polyzoa S. HARMER (1892) proved the excretory activity of the leucocytes as well as other cells of the body, by keeping living colonies in sea-water holding the fine powder of various insoluble colouring matters in suspension. After doing so for a short time he found that the fine grains were greedily devoured by the leucocytes. CORI, who carried on similar experiments with *Cristatella*, observed that the same was the case with Phylactolamatus Polyzoa. Moreover he found that cells charged with excretory substance were from time to time expelled through the external pore of the ciliated tubes. It is thus certain that the true excretory part in Polyzoa is represented by the floating cells or leucocytes, as KOWALEVSKY proved by his beautiful experiments with certain worms.

Although I have not seen actually a polypide discharging the leucocytes, a careful examination of these cells, especially those accumulated in the ciliated tubes, convinces me of the very high probability of the above phenomenon occurring in *Pectinatella*. If we take a living colony and observe it under the microscope, we find a great number of round or oval cells circulating in the body in a pretty rapid stream. Some of them, which I compared erroneously with blood-corpuscles of other animals in my former paper (1890), are filled up with a vacuole containing a liquid of a pale yellowish colour. Others, again, show a few vacuoles of smaller dimensions or a large number of minute ones. In stained preparations, they look much like the figures given by CORI. In sections I found them most abundant in the epistomal cavity or along the great retractor muscles. In most of them the nuclei bear signs of degeneration, the chromatic substance being sometimes melted together to form a conspicuous deeply-staining ball. As such cells are always found accumulated in the unitubular portion of the ciliated canals, I am inclined to believe that they are thrown out, together with the excretory substance held by them, in the manner described

by CORI. I may quote here a remark by this author and thus conclude the consideration of the subject. "Die Niere der Bryozoen ist nicht mehr selbst exkretorisch thätig, indem sie nicht selbst durch ihre Epithelien gewisse Stoffe ausscheidet, sie dient vielmehr nur als ein Ableitungs-organ für die mit Harnstoffen beladenen Lymphzellen." CORI supposes this condition is a product of retrogression; I, on the contrary, regard it as a primitive one from the reasons to be given at the end of this paper.

Let us now examine what we know concerning a similar structure in the other group of the Ectoproctous Polyzoa.

*Excretory Organ of Gymnolematous Polyzoa.* Our knowledge of the excretory organ of Gymnolematous Polyzoa is next to nothing. The whole literature of the subject consists of a short notice by FARRE (1837) accompanied by two figures, and the remarks of HINCKS (1851) and SMITH (1866), both of whom do not go beyond confirming FARRE's observation. FARRE found in *Membranipora pilosa* and *Acyonidium gelatinosum* a bottle-shaped organ, ciliated internally, situated between the tentacles and terminating in a ciliated funnel. Contrary to all the segmental organs, it lies floating in water outside the body of the polypide and communicates with the body-cavity only at its lower extremity. This organ is, according to FARRE's figures, altogether different from the structure described in the present paper, so that a homology between them is out of the question. Besides, all the above observations are of a comparatively early date, and strangely enough, have not since been once confirmed. For instance, JOLIET (1880), who searched specially for this organ in one of the species mentioned above, namely, *Membranipora pilosa*, came only to negative results. I could not find any such organ, either, in various species of *Scrupocellaria* and *Bugula* which I examined in sections. As already proved by HARMER, the leucocytes and the cells of the peritoneal

lining of marine Polyzoa take up foreign substances, and it seems very probable that there exists some passage for the exit of these cells, presumably at the place corresponding to that in fresh-water forms. Perhaps the semilunar pore of *Microporella* discovered by PERGENS (1889) might be of this nature.

From the observations summed up above, I come to the conclusions, 1) that marine Polyzoa have no structure comparable with the ciliated tubes of *Phylactolemata*, and 2) that the existence of a minute pore putting the body-cavity in communication with the exterior is highly probable. At any rate, a thorough investigation of marine Polyzoa with regard to this point is very much to be desired.

#### *Nephridium of Endoproctous Polyzoa.*

It was HATSCHEK (1877) who first noticed the existence of the nephridium in *Pedicellina*. In his admirable paper "Über die Embryonalentwicklung und Knospung der *Pedicellina*," this author describes a fine ciliated canal situated in the body-cavity, in the neighbourhood of the ganglion, with one end opening exteriorly, but whose terminations could not be determined positively. He says: "Trotz Anwendung von stärkeren Vergrößerung (Hartn. Imm. 10.) war es nicht möglich das hintere und vordere Ende genau zu verfolgen. Doch schien mir das Hinterende mit einer schwachen Erweiterung in die Leibeshöhle zu münden, das vordere Ende aber mit den dunkelkörnigen drüsenähnlichen Mesodermzellen in Verbindung zu stehen, die zum Theile wenigstens eine reihenweise Anordnung zeigen und in welchen ich mehrmals einen Kanal zu verfolgen glaubte; doch sind mir diese Verhältnisse sehr zweifelhaft geblieben." JOLIET who investigated this organ in *Pedicellina* and *Loxosoma* came to more satisfactory results. To quote his own



words:—"Ceux-ci (the vibratile organs) sont deux canaux assez courts, atténués vers l'extrémité, renflés au milieu, formés, d'après Hatschek, de cellules perforées, mais où je n'ai pu distinguer, avec des grossissements supérieurs à ceux employés par cet auteur, qu'une obscure division transversale, sans qu'il m'ait été possible de constater une structure cellulaire bien nette. Le pavillon, qui termine chaque canal ressemble à un entonnoir taillé en bec de flute, fendu sur la ligne médiane sur une certaine longueur et dont le bord libre serait épaissi en bourrelet sur une certaine étendue et se prolongerait plus loin en un lèvre délicate." As to the physiological rôle of these organs, the author does not give anything definite; he only denies their service as evacuatories for the genital products. He remarks further, concerning their function: "Les parois de ces canaux sont si minces, qu'elles ne peuvent guère être regardées comme glandulaires et formant un organe excréteur," but later investigations have shown that this is not strictly true.

About five years later than the last paper, HARMER (1885) published the results of his investigations on the anatomy and development of *Loxosoma*. He studied the nephridium of this animal very closely, and his short but precise statements have since been, in the main, confirmed by FOETTINGER (1887), another investigator of this organ, who two years later than HARMER, wrote a valuable article on the *Pedicellina* of Ostend. What I have been able to observe in *Barentsia misakiensis* also agrees with the results of these two authors, except on a few points of secondary importance. HARMER found, namely, the nephridia of *Loxosoma* lying on the ventral wall of the stomach, one on each side of the œsophagus, and situated near the anterior surface of the body. He says:—"the proximal part consists of a small number of cells, which, in opposition to JOLIET's statement, I consider undoubtedly excretory in function.....The distal portion of the nephri-

dium is a colourless duct, which presumably has no excretory function.....It seems to me certain that the two nephridia open independently, their apertures occurring in the depression of the vestibular floor situated behind the epistome ; there can be no doubt that the nephridia open to the exterior in front of the ganglion." He believes, further, the proximal cell to be a flame cell, although he could not ascertain it positively.

The account of the nephridia of *Pedicellina* given by FOETTINGER is nearly the same as HARMER'S, but differs from it as regards the mode of opening of the tubes. Instead of opening independently as in *Toxosoma*, these tubes unite in *Pedicellina* at a certain distance from the external orifice, which is found at the bottom of an infundibuliform depression. He adds, "J'ai pu, sur des coupes verticales passant par les faces latérales du calices, m'assurer de la façon la plus positive que les deux canaux segmentaires, chez le mâle et chez la femelle, possèdent une portion commune, impaire et médiane, débouchant à l'extérieur." As to the nature of the proximal cell, he remarks, "chez *P. echinata*, tout aussi bien que chez *P. Benedeni* et que chez *P. belgica*, la cellule terminale possède un faisceau de longs cils s'engageant assez loin dans le canal."

According to my observations, the nephridia of *Barentsia misakiensis* seem to stand intermediate between those of the two genera already investigated, in the manner of opening externally. Here the tubes unite before they open to the exterior, as I have stated elsewhere (1895a), but not at such a considerable distance inward as in *Pedicellina belgica*. They coalesce, rather, almost at the place, where they open into the funnel-shaped pit of the body-wall mentioned by HARMER and FOETTINGER, so that the unitubular portion of the nephridia is extremely short. In this respect the description of JOLIET applies completely to our species ; "l'observation de l'objet vivant avec un grossissement

montre avec toute la netteté désirable que le canal s'attache sur la matrice assez près de la bouche ; on voit aussi dans ces conditions que son congénère aboutit presque, sinon tout à fait, au même point." On the structure of the proximal cell, my results are identical with those of FOETTINGER.

To sum up, the nephridia of Endoproctous Polyzoa are constructed on the same plan as those of mesenchymatous worms. They are tubular in form and consist of a row of drain-pipe cells, of which the proximal one is a flame cell. It is very evident that, from a phylogenetic point of view, the so-called excretory organs of the fresh-water Polyzoa have nothing to do with these organs.

#### *Nephridium of Phoronis.*

The affinity of this genus with the Polyzoa proper is so great, that it has been counted by some authors (LANKESTER, MACINTOSH) among Polyzoa, as constituting the section *Vermiformia*. It should be, therefore, of great importance in discussing the morphological value of the so-called excretory organs of fresh-water Polyzoa, to give first a correct representation of the nephridia of *Phoronis*.

The nephridia of *Phoronis* have already been studied by a number of investigators (DYSTER 1858, KOWALEVSKY 1867, CALDWELL 1882, M'INTOSH 1888, BENHAM 1889, CORI 1890). The articles by the last three authors on *Phoronis*, especially, deal with the subject very minutely, and in some respects supplement one another, so that a further investigation seemed almost unnecessary. And so it proved, for my observations brought out no new facts and only confirmed the statements of previous authors.

With regard to the general structure of this organ in *Phoronis psammophila*, CORI writes : "Das Nephridium der *Phoronis* stellt

einen bewimperten, schleifenförmig gekrümmten Kanal vor, an welchem man einen absteigenden Schenkel unterscheidet, der sich mittels eines offenen Flimmertrichters mit der unterhalb des Diaphragmas gelegenen Leibeshöhle in Verbindung setzt, dann einen aufsteigenden Schenkel und schliesslich ein Endstück, das mit einer Oeffnung nach aussen mündet. Was die Lage dieser schleifenförmigen Nierenkanäle im Körper anbelangt, so sehen wir, dass dieselben hinter dem Diaphragma zu beiden Seiten vom Endabschnitte des Dünndarnes sich finden und dass sie ausserhalb der Leibeshöhle als retroperitoneal gelagert sind." This applies, with a little modification as to position, to the nephridia of *Ph. Kowalewskii* also. In *Phoronis*, the nephridia are special organs of a tubular form, serving to connect the body-cavity with the exterior. In this respect, these organs may be compared with the nephridium proper or metanephridium of coelomatus animals, so-called in contradistinction to the pronephridium which includes such forms as the excretory organ of mesenchymatous worms or that of the Endoprocta.

CORI homologizes the ciliated tubes of fresh-water Polyzoa with the nephridia of *Phoronis*, apparently without hesitation; for he assigns to the former a structure in every respect analogous to that of the latter. Such a conception naturally results, it appears to me, from a not sufficiently accurate interpretation of the cross sections, some of which, indeed, are very liable to be misconceived. No one looking at CORI's fig. 4, Pl. XXIV (1890) for instance, and fig. 9 at the end of this paper, would find it difficult to accept the homology of the pairs of oval sections in them. A comparison of my diagrammatic figures of Polyzoa with any figure of the nephridium of *Phoronis*, however, will show immediately that the resemblance in this case is only a deception and has no value whatever in the consideration of the organs in question.

*Conclusions.*

From my investigation of the true bearings of the so-called excretory organ of fresh-water Polyzoa, I have come to the following conclusions.

In Ectoproctous Polyzoa, the excretory function is carried on by free mesodermal cells or by the cells of the lining epithelium of the body-cavity. These cells take up the excretory matters and are then driven out of the body through a certain pore in the body-wall. In order to carry these cells laden with refuse substance to this pore, a portion of the peritoneal epithelium immediately surrounding it is provided with cilia, and is also thickened to provide for the increased quantity of energy wanted in moving the latter. The pore is situated on the anal side of the body at the base of the median tentacle, presumably in every Ectoproctous Polyzoa.

In Phylactolæmatous Polyzoa this relation is so far complicated that the cavity of the epistome is separated completely from the remainder of the body-cavity by a special partition, having the form of an inverted V, at the apex of which the pore opens. As the tentacles near the median line lie somewhat higher than the rest, it results that in a few cross sections we see the mesodermal epithelium of the body-wall and that of the V-shaped partition joined in two circles, one on either side of the median line (see fig. 9, Pl. XXXV), and looking exactly like cross sections of tubes. At this place the epithelium is much thicker than at any other and is, besides, provided with well developed cilia. These facts were certainly the chief grounds for the opinion, that the peculiar structure treated of in this paper are nephridia.

In Gymnolæmatous Polyzoa there is no epistome and consequently no partition between the epistomal and lophophoral cavities. That we

should meet in this group with no structure comparable to the so-called excretory organ of the fresh-water forms, becomes very clearly intelligible when the above account of the matter is accepted. If, on the contrary, we assume the nephridial nature of the structure in fresh-water Polyzoa, then its total absence in marine forms becomes inexplicable. Again, that the pore has been discovered only in a few of the marine Polyzoa, does not necessarily prove that it is actually absent in all the rest, for it is a very difficult task to ascertain its existence in sections. Even in Phylactolematous Polyzoa, in which we know of its existence, it is almost impossible to demonstrate it in many cases.

To sum up:—*The Ectoproctous Polyzoa have no nephridia. What have been regarded as such in Phylactolemata, is nothing but a portion of the mesodermal epithelium of the body-cavity, made conspicuous by the presence of an epistome-lophophoral partition, wanting in Gymnolemata.*

Comparing the Ectoprocta with the Endoprocta and Phoronis as regards the nephridia, we have the following remarks to make.

1. Endoproctous Polyzoa have pronephridia, or that type of nephridia which is found only in the mesenchymatous worms. This and the fact that they have no true body-cavity, show us that the Endoprocta should be separated from the Polyzoa proper, the Ectoprocta, and placed somewhere in or near the group of mesenchymatous worms in a systemic arrangement.

2. *Phoronis* resembles the Ectoprocta very greatly at first sight, but when we compare the two forms more minutely, we find that in reality the difference between them is greater than at first appears. To say nothing of the orientation of the body, which might be very different in these groups, as some authors have already pointed out, or the existence or non-existence of a cartilaginous

skeleton, there are still the main differences concerning the nephridia and blood-vessels. While *Phoronis* has well developed metanephridia that serve at the same time as the passage for the exit of genital products, the Ectoproctous Polyzoa have no structure comparable to it, the excretory function being here carried on chiefly by leucocytes. *Phoronis* has a set of closed blood-vessels besides the colon, whereas in the Ectoprocta it is the perigastric fluid that circulates through the body. These differences are indeed very great, and should certainly be taken into consideration in discussing the genetic affinity of these animals. After weighing these and other important structural differences against the superficial resemblance which they present, we come unconditionally to the conclusion that *Phoronis* approaches the Sipunculids more than it does the Ectoproctous Polyzoa.



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### Explanation of Plates.

<i>a.</i>	Anus.	<i>int.</i>	intestine.
<i>cep.</i>	epistomal cavity.	<i>l.</i>	lophophore.
<i>cg.</i>	ganglionic cavity.	<i>m.</i>	mouth.
<i>cpst.</i>	perigastric cavity.	<i>oes.</i>	oesophagus.
<i>dphr.</i>	diaphragm.	<i>plep.</i>	epistomo-lophophoral partition.
<i>g.</i>	ganglion.		

0, 1, 2, 3, 4, 5, tentacles, counted from the median line of the body.

### Plate XXXIV.

*Fig. 1.* Distal portion of a polypide cut open longitudinally, somewhat diagrammatic.  $\times 140$ .

*Wct 1, 2, 3, 4.* show approximately the levels at which the cross-sections would appear as represented in Woodcuts 1-4.

Red lines with ciphers, at the right hand of the figure, show the levels of figures with corresponding numbers in the same plate.

*Figs. 2-7.* Cross sections of the so-called nephridium with neighbouring portions of the polypide. Taken from an individual with an unpaired median anal tentacle.  $\times 500$ .

### Plate XXXV.

*Fig. 8.* A cross section, from the same individual as figs. 2-7.  $\times 500$ .

*Figs. 9-11.* Cross sections of the so-called nephridium with neighbouring portions of the polypide. Taken from an individual without an unpaired median anal tentacle.  $\times 500$ .

*Figs. 14-15.* Diagrams showing the relations of various cavities at the distal portion of a polypide.

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# On the Dendritic Appendage of the Urogenital Papilla of a Siluroid.

By

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*With Plate XXXVII.*

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In spite of the fact that all the siluroid fishes included in the genus *Plotosus* have long been known to possess a peculiar dendri-form appendage behind their urogenital papilla and that its external features have repeatedly been described, only imperfect knowledge exists of its internal structure and physiological significance. It

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\* It is my painful duty to record here the death of the author of the present article. Some time before his last illness, Mr. HIROTA placed in my hands the manuscript of the article, which had already been so far worked over that after his death, I found myself able to put them into the final shape for publication. The alterations that I have taken the liberty of making are only such as in my opinion bring out his ideas more clearly and would, I believe, have been accepted by him if he had been alive. In no case have I wittingly run counter to his ideas. At the same time I must ask the reader's kind consideration of the circumstances if some parts are found to be not as full as may seem desirable. I can not let this opportunity pass without saying that we have lost in Mr. HIROTA a co-worker of great promise. His published articles besides the present one are as follows:—

1. On the Sero-Amniotic Connection and the Foetal Membranes in the Chick. *Jour. Coll. Sci., Imp. Univ. Japan Vol. VI. 1894. English.*
2. On the Fauna of the Ogasawara (Bonin) Islands. *Zool. Mag., Tōkyō, Vol. VI., Nos. 68 and 69, for June and July, 1894. Japanese.*
3. On the Loss of Weight in the Fowl's Egg during Incubation. *Zool. Mag. Tōkyō, Vol. VI., No. 74 for Dec. 1894. Japanese.*
4. Anatomical Notes on the 'Comet' of *Linckia multifora*, LAM. *Zool. Mag. Tōkyō, Vol. VII., No. 78 for April 1895. Japanese and English.*
5. Notes on a Scink with an Accessory Tail. *Zool. Mag. Tōkyō, Vol. VII., No. 81 for July 1895. Japanese and English.*

Besides these, he published several short notes in the Zoological Magazine of Tōkyō.  
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is true that J. BROCK<sup>1)</sup> made a microscopical study of the appendage in question in *Plotosus anguillaris* (BLOCH) LACER., but as his materials were confined to four immature specimens, the results of his investigation were not entirely satisfactory.

Last year, at the suggestion of my friend Mr. T. KITAHARA, I undertook a new investigation of the appendage in *Plotosus anguillaris* already studied by BROCK. This fish is easily obtainable at the Marine Biological Station at Misaki throughout all seasons, so that the supply of my materials was practically unlimited, and I was able to examine the organ in a large number of fresh as well as alcoholic specimens of both males and females in various stages. The following notes containing the results of my investigation are, I regret to say, purely morphological, but it is hoped that they may throw some side light on the physiological function of the organ, for the determination of which future research is however still needed.

Before going further, I wish to express my deepest indebtedness to Prof. Dr. MITSUKURI for kind supervision of my work and to Mr. T. KITAHARA for valuable advice.

### External Parts.

As a full description of the external parts of the appendage seems at the present day hardly needed, I shall introduce here only such remarks on the general features of the organ as will make what follows intelligible along with others about it in its fresh state and in its early stages.

Fig. 1, Pl. XXXVI. represents in their natural size the appendage and the adjacent parts in a fully grown individual.

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1) Brock, J., Ueber Anhangsgebilde des Urogenitalapparates von Knochenfischen. *Zeit. f. wiss. Zool.* Bd. 45, 1887.

The appendage occupies a comparatively wide space behind the urogenital papilla and is so situated as to be more or less protected by the paired pelvic fins. It is very soft and pliable, and is in its natural state blood-red in colour. It is, as a whole, divided into two symmetrical halves, each of which is again subdivided into numerous thin lobes of various sizes. Figs. 3-5 represent three different aspects of one and the same specimen: Fig. 3 is the dorso-anterior, Fig. 4 the ventral, and Fig. 5 the dorsal, view. The whole organ is lodged in a depression (Fig. 2) of the body proper, corresponding in shape to the dorsal surface of the organ, in a manner represented in Fig. 10. On a ventral view, the urogenital papilla anteriorly, and the front end of the caudal fin posteriorly, are received between the two divisions of the appendage. At the bottom of the depression just mentioned, there is a collar-like structure (*collar* Fig. 2) surrounding a central pit (marked *fissure*, Fig. 2). Into this pit is inserted the stalk of the appendage by which it is connected with the body-proper and which is situated rather nearer the anterior end of the organ. There is between the stalk and the collar a distinct canal all around except at the anterior median line where the stalk is adherent by a narrow strip to the urogenital papilla. The size of the appendage may vary in different individuals of the same stage. The largest found among about four dozen specimens of adult individuals is 8 mm. in length and 12 mm. in breadth, while the individual to which it belongs measures 180 mm. in total length.

If we examine a lobe or leaf of the appendage under a magnifying lens, we observe numerous more or less round deep pits of different sizes on its surface (Fig. 6). Examined in a fresh state, these pits are found to be in meshes of a fine net-work of capillaries as represented in Fig. 7. Also in the same state numerous branching blood-vessels are seen in the interior, (Fig. 11) although they are rather obscure in

the thicker parts. In fact, the characteristic colour of the organ is caused by these blood-vessels and capillaries.

The dendritic appendage is found equally developed in the two sexes as was, according to Brock, ascertained by Kner in 1855; in fact the sex can be determined only by an examination of the generative organ. The appendage is also found from the very earliest stages of growth being simpler in structure, the earlier the stage. For instance, Fig. 9 represents somewhat enlarged the organ belonging to the very young individual shown in Fig. 8 in its natural size. It is already divided into two more or less symmetrical halves but each half consists only of a few lobes marked with shallow pits. It is at this stage coloured not only by blood but like the body proper by fine dots of black pigment which becomes dispersed and almost invisible in the adult.

In passing, I may remark that Brock's Figs. 1 and 2 appear to me somewhat unfortunate as representations of nature. His Fig. 1 almost makes me think that the species he observed is different from mine,<sup>1)</sup> but the difference probably arises from the unsatisfactory state of his preserved specimens.

### Internal Structure.

When we cut the organ in question into serial sections, we soon observe that it is built up of two concentric zones, of which the outer or the cortex consists of a parenchyma-like epidermis containing also slime cells and well developed glandular cells, while the inner zone or the corium consists of smooth muscular

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1) For specific identification, I have mainly relied on Günther's *Cat. of the Fishes in the Brit. Museum*, but have also referred to Desmarests' *Hist. Nat. de Lacépède* and to Schlegel's *Fauna Japonica, Poiss.*

fibres containing blood-vessels, lymph-cavities and nerve-bundles. Particulars concerning each of these zones are briefly stated in the following paragraphs.

### *The Cortex.*

In describing the cortex it is convenient to consider separately the parenchyma-like epidermis and the glandular cells, although the two stand in close relations with each other. The parenchyma-like epidermis is, as shown in Figs 20 and 21, formed of densely packed simple epidermal cells with ordinary round or oval nuclei and of scattered bottle-shaped slime cells (*sl*) with short ducts. In or near the stalk of the organ, the epidermis forms a thick continuous stratum and is the sole component of the cortex in that part (Fig. 18). In the more distal portion, *i.e.*, in the thin lobes of the appendage, it is interrupted by numerous pits in which it suddenly thins itself out and at their bottom exposes the heads of underlying glandular cells to be spoken of immediately (Fig. 20). The slime cells are found only in those regions where the epidermis attains a certain thickness and are entirely absent from the pits.

Longitudinal sections of the basal portion of the appendage show that the epidermis is directly continuous with that of the body proper (Fig. 18). In both parts, the epidermis is exactly alike in structure, except that in the appendage it is interrupted by numerous pits, the bottom of which is always occupied by glandular cells. In the body proper, these glandular cells are entirely absent, although quite a different sort of gland-cells known as goblet cells are present (Figs. 18 and 19). The slime cells are few in number in the stalk but they can be traced in longitudinal sections right to the body proper without any great gap in the series. They are, in the appendage and the body

proper, exactly alike not only in shape and occurrence but also in the fact that they are distinctively stained by Kleinenberg's hæmatoxylin solution.

Let us next examine the glandular cells in the pits which form such a characteristic feature of the appendage. As Figs. 20 and 21 show, they are uncommonly large cells, always filled up with finely granular substance and containing a single oval nucleus in about the middle of their length. In a section, they are seen standing side by side in a single row along the bottom and sides of every pit and exposing their heads directly into the cavity of the pit, although the nuclei of the epidermal cells are seen here and there scattered over them. A group of the glandular cells belonging to one pit forms a sort of cup, more or less distinctly separated from neighbouring groups or cups by the intervening epidermal cells, capillaries, etc. (Figs. 19 and 20); so that the glandular cells do not form a single continuous sheet as supposed by Brock. It is evident from the above description that the secretory product of these glandular cells is discharged directly into the cavity of the pit through the interruptions of the epidermis. In specimens killed with chromic acid or chromo-acetic acid, the granular contents are well stained with alcoholic or watery solutions of such aniline dyes as eosin, methyl-blue, and saffranin, but do not absorb Kleinenberg's hæmatoxylin solution which differentiates the slime cells.

In the body proper as well as in the basal portion of the stalk, there are found, as I have mentioned above, instead of such true glandular cells, a number of large ductless goblet-cells at the inner part of the epidermal layer (Figs. 18 and 19). In the fully developed stage, these two kinds of cells are distinguished from each other by the following points:—

- a) The glandular cells of the appendage form definite groups,



while the goblet cells are scattered or at least separated from one another by interstitial cells.

b) The goblet cells are usually multi-nucleated — containing sometimes as many as four nuclei — while the glandular cells have never more than one (Figs. 18 and 21).

c) The goblet cells which are deeply imbedded in the epidermis have no opening, while the glandular cells are directly exposed externally.

d) The goblet cells are always much larger than the glandular cells, being often as much as ten times in volume (Fig. 19).

e) The glandular cells are without exception filled with finely granular thick contents, while the contents of the goblet cells are partly or entirely very coarse-grained.

f) As Fig. 19 shows, there is no gradual transition between the goblet, and the glandular cells, an abrupt replacement taking place.

In a young animal, such as is represented in Fig. 8, the glandular cells of the dendritic appendage are as yet only slightly larger than the surrounding epidermal cells, but they are already directly exposed at one end in the bottom of diminutive pits (Fig. 22), although it is doubtful whether they are actually functional or not. In such a stage differences between these cells and the goblet cells are not as clear as in the adult, but it is noteworthy that the former are found in groups, while such is never the case with the goblet cells in any stage. It would, however, require further embryological research to decide whether the glandular cells are metamorphosed goblet cells or are independently developed in this particular organ.

The first writer who pointed out the presence of the pits or “Krypten” and of the glandular cells in the appendage is Brock. In his sections, he, however, found ordinary epidermal cells in the

bottom of the pits overlying the glandular cells, and he was at a loss to account for the way by which the secretory product of the glandular cells was discharged into the cavity of the pits. He supposed that the condition found in his sections was due to the fact of his specimens being immature, and that in the adult, the epidermal cells were removed from the bottom of the pits, thus exposing the glandular cells. This statement is somewhat remarkable, as even in specimens much younger than those studied by him, the glandular cells are freely exposed at the bottom of the pits, as I have stated above (see Figs. 8 and 22). It is possible that his sections were cut somewhat obliquely and thus failed to show the true state of things. The glandular cells are also stated by Brock to form a continuous layer, whereas in reality every group is discontinuous from the adjacent ones.

### *The Corium.*

The inner zone of the dendritic appendage consists of smooth muscular fibres containing nerves, large blood vessels, and irregularly branched lymph-cavities. From sections we learn that this inner zone attenuates in thickness from the stalk towards the tips of the lobes. In the latter position, it is thicker in the middle than towards the edges. In longitudinal sections of the basal portion of the stalk, showing the connection between the appendage and the body proper (Fig. 18), we observe that the peripheral part of the muscular zone is directly continuous with the corium of the body proper, while the middle part runs deeply inwards to attach itself to the ventral apophyses of the vertebrae, mainly to those of the second and third caudal vertebrae and partly to those of the first<sup>1)</sup> and fourth.

Blood is supplied to this appendage by a pair of arteries which

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1) I designate the first vertebra which forms the haemal arch by a bony bar the first caudal vertebra. It is perhaps the third according to Brock's nomenclature.

arise at the same level from the dorsal aorta behind the first haemal arch (Fig. 10). Their courses may vary more or less in different individuals: both of them may run in behind (as is represented in Fig. 10), or before, the coalesced apophyses of the second caudal vertebra or one of them may pass before, and the other behind, the same apophyses. They may send off small branches before entering the stalk of the appendage. In all the cases I have examined, I have found them symmetrically paired in the basal portion of the stalk (Fig. 13). As they proceed centrifugally, they divide and subdivide in the usual manner, until they end in capillaries forming the network around the pits of the lobes.

The venous vessels which arise from the capillaries become gradually larger as they proceed centripetally by the union of smaller vessels. In the distal portion of the stalk (Figs. 14 and 15), they are already united into two main trunks, each coming from the corresponding half of the appendage. Sooner or later before entering the body proper, these two are also fused into one (Fig. 13). In the body proper it passes behind or before the ventral apophyses of the second caudal vertebra and opens into the cardinal vein at about the level of the origin of the arteries (Fig. 10), and in company with a pair of veins coming from the abdominal wall on both sides. Figs. 13-16 represent selected transverse sections of the stalk between its base where it is attached to the urogenital papilla and the point where it divides into two, and Fig. 17 is a horizontal section cut through the plane indicated by the letter (*a*) in Fig. 3. In such transverse sections, it is natural that some of the blood vessels should be cut obliquely or one and the same vessel should appear two or three times in one section on account of its being bent or curved in its course. But in spite of these circumstances it is clear from these figures that all the larger vessels belong to the venous system and are monstrously large

in proportion to the arterial system as well as to the appendage itself.

The nerves are supplied to the appendage from a pair of spinal nerves sent out from the first caudal vertebra (Fig. 10). These spinal nerves give near the root of the appendage one branch on each side of the body which enters directly into the appendage and innervates it. They run similar courses to the arteries but begin to branch sooner than the latter. I have been unable to trace these bundles into their final twigs, but I have recognised them in sections near the tips of the lobes (Fig. 17).

Besides these blood-vessels and nerves there is observed in the inner zone of the appendage still another system of cavities, *i.e.*, that of the ill-defined lymph-cavities (Figs. 13-16). In serial sections it can be traced in the body proper to the dorso-median lymph-cavity surrounding the aorta and the cardinal vein. Near the base of the stalk (Figs. 13 and 14), it may be branched into a pair or be simple, but on its further course, (Figs. 15 and 16) it sends out here and there several irregularly shaped branches. It is bounded by an endothelial membrane while it passes through the connective tissue of the body proper, but in the appendage from the base of the stalk upwards, there exists no longer a definitive boundary. Owing to this circumstance, the cavities have often collapsed by bad treatment and the lymph-cavity appears then as if it ended blindly near the root of the stalk. It can be traced for a certain distance towards the lobes of the appendage but in the latter it vanishes in the loose fibrous tissue.

All these structures of the corium are equally well observed in various younger stages. Even in such a stage as is represented in Fig. 8, there are already recognisable in the cross-sections of the stalk a pair of arteries, a vein of considerable size, and a lymph-cavity of suitable proportion in the same relations with one another as in the adult (Fig. 12). The only noteworthy peculiarities of such a stage are the

apparent absence of nerve-bundles and the presence of pigment cells. The first circumstance is perhaps owing to the difficulty of distinguishing nervous from muscular fibres in such a young stage, while the second circumstance is due to the small size of the organ in which the pigment cells have not yet begun to disperse. At all events, the general plan of the structure of the inner zone can be made out in such an early stage.

The inner zone has already been examined by Brock. The lymph-cavities as well as nerve-bundles seem to have escaped his notice while he considered the veins as the most important part of the organ. He says:—"Das ganze Organ wird vom Stiel bis in seine feinsten Verzweigungen von ungeheuer entwickelten Bluträumen entnommen, die zum Theil noch mit geronnenem Blute dicht gefüllt sind (Fig. 3 s). Diese Bluträume sind begrenzt von mächtigen Balken (Fig. 3 m), welche überwiegend in der Längsrichtung der einzelnen Zotten angeordnet sind, so dass die Bluträume polygonale langegezogene Maschen bilden, welche unter einander in offener Verbindung stehen \* \* \*." These large blood-spaces he considers a part of the venous system. Then he proceeds to say "dass wir hier ein typische cavernöses Gewebe vor uns haben" and "dass ein Organ in dem wir cavernöses Gewebe in überwiegender Menge vertreten finden auch erektil sein muss." Thus, according to Brock, the whole inside of the organ is, so to speak, nothing but large anastomosing blood spaces and under the circumstance the organ itself must be erectile. From the description which I have given above, it will not be surprising that I find myself unable to accept these statements of Brock's. It is true that in some longitudinal sections through such parts as are given in Fig. 16 where numerous branches of veins and of lymph-cavities are present we often meet with a picture which reminds us of Fig. 3 of Brock's paper, but if we trace the so-called "Bluträume"

and " Balken " in serial sections, we soon discover that the former are nothing but the swollen dendritic and not anastomosing branches of blood-vessels and that the latter are not bars but tissues separating the bloodvessels. The erectile nature of the organ seems therefore highly doubtful. From the description which I have given in the preceding pages it seems to me evident that the appendage in question is a *highly developed gland*. The enormous surface-extension of the organ and the unusual development of the venous system may be taken as the indications of its importance and activity. Its presence in both sexes and its early development must be taken into account in any explanation of its physiological significance. We are for the present obliged to leave it to future research to determine in what period of life or on what occasions it is actually functional and what service it then renders.



## Explanation of Plate XXXVI.

Abbreviations: *A*, arteries; *cap.*, capillaries; *Depr.*, pits; *Gl.*, glandular cells; *Gob.*, Goblet cells; *Sl.*, slime cells; *u. g. p.*, urogenital papilla; *V*, veins.

*Fig. 1.* General view of the dendritic appendage and its adjacent parts. Nat. size.

*Fig. 2.* Represents the anus, the urogenital papilla, and the depression of the body into which the dendritic appendage is received, together with the stalk of the appendage cut at its base, thus exposing the collar and the central pit (fissure) at the bottom of the depression.  $\times 2.7$ .

*Fig. 3-5.* Represent respectively the dorso-ventral, the ventral, and the dorsal views of the dendritic appendage. The stalk is cut off at about its middle.  $\times 2.7$ .

*Fig. 6.* Surface view of a lobe or leaf of the appendage under a magnifying lens. Black spots represent pits.  $\times 9$ .

*Fig. 7.* Surface view of a part of a lobe. Red lines represent capillaries and black areas pits. Highly magnified.

*Fig. 8.* Young *Plotosus*. Its dendritic appendage is represented in Fig. 9. Nat. size.

*Fig. 9.* Dendritic appendage of a young *Plotosus* represented in Fig. 8. Fine black spots on the surface represent pigment.  $\times 18$ .

*Fig. 10.* Represents diagrammatically the origin of blood-vessels (red lines) and of nerves (black line) which enter the dendritic appendage. An artery and a nerve on the opposite side are not represented.

*Fig. 11.* Surface view of a lobe, seen under a magnifying lens by transmitted light, showing blood-vessels.

*Fig. 12.* Transverse section of the stalk of the very young dendritic appendage shown in Fig. 9. The peripheral light area represents the cortex, the red rings arteries and the vein, and the light black ring the lymph-cavity.

*Fig. 13-16.* Selected transverse sections of the stalk. Fig. 13 is taken from that portion of the stalk where it is adherent to the urogenital papilla and Fig. 16 from the level where the appendage is bifurcated. There are 114 sections between Fig. 13 and 14, 39 between Figs. 14 and 15, and 55 between Figs. 15 and 16. Red and light black rings represent the same structures as in Fig. 12. Black dots represent nerve-bundles. Zeiss 2aa.

- Fig. 17.* Transverse section of lobes through the line pointed to by the letter *a* in Fig. 8. Zeiss 2.aa.
- Fig. 18.* Longitudinal section of the basal portion of the stalk showing the connection between the dendritic appendage and the body proper. This section is somewhat to one side of the axis of the stalk, and in this particular case the collar-shaped skin-fold is rather rudimentary, though it is more marked in the median sections than in this. The upper end of the figure is directed towards the tail. Zeiss 2.aa.
- Fig. 19.* Longitudinal section of the stalk showing the sudden replacement of the goblet cells by the glandular cells. Zeiss 2.BB.
- Fig. 20.* Transverse section of a lobe of the dendritic appendage in a fully grown individual. Zeiss 2.DD.
- Fig. 21.* Highly magnified view of a group of glandular cells. Zeiss 2.F.
- Fig. 22.* Highly magnified view of a part of transverse section of a lobe belonging to the dendritic appendage given in Fig. 9. Zeiss 2.F.







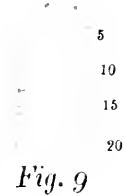
*Fig. 1*



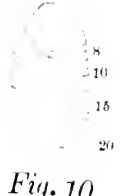
*Fig. 2*



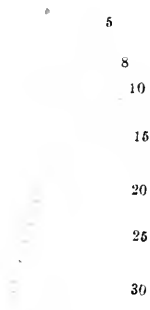
*Fig. 3*



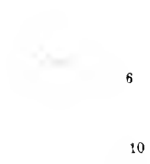
*Fig. 9*



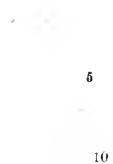
*Fig. 10*



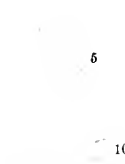
*Fig. 11*



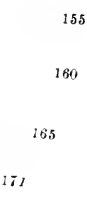
*Fig. 4*



*Fig. 5*



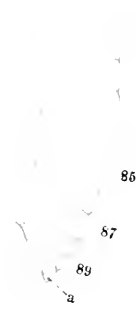
*Fig. 6*



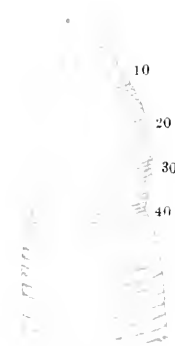
*Fig. 12*



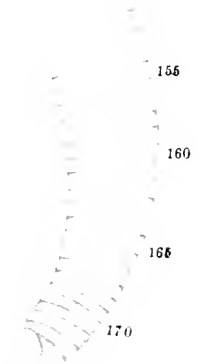
*Fig. 7*



*Fig. 8*



*Fig. 13*



*Fig. 14*



A

B



V

V

V

V



V

V

V

V



V

V

V

V



V

V

V

V



V

V

V



V

V

V



Fig. 1

Fig. 3

oc.

10 15 20 25 27 30 32 35 40

oe.

rd.

n.

oe.

rd.

nph.

vnph.

Fig. 2

st.

Fig. 4

n.

vv.

sv.

caec.

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vv.

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inf.

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vnph.

Fig. 6

cv.

Fig. 5

u.

sp.

Fig. 7

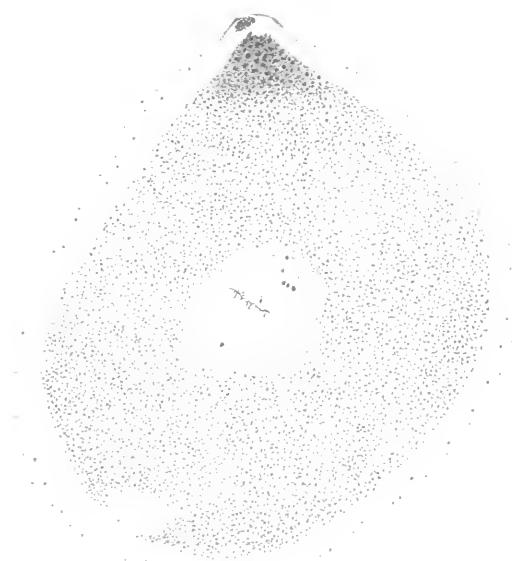
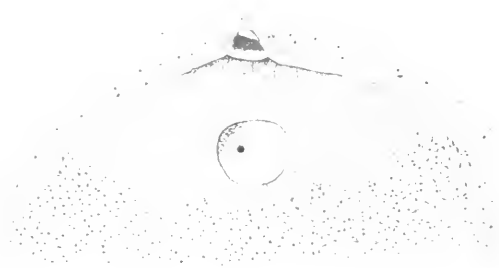
Fig. 8













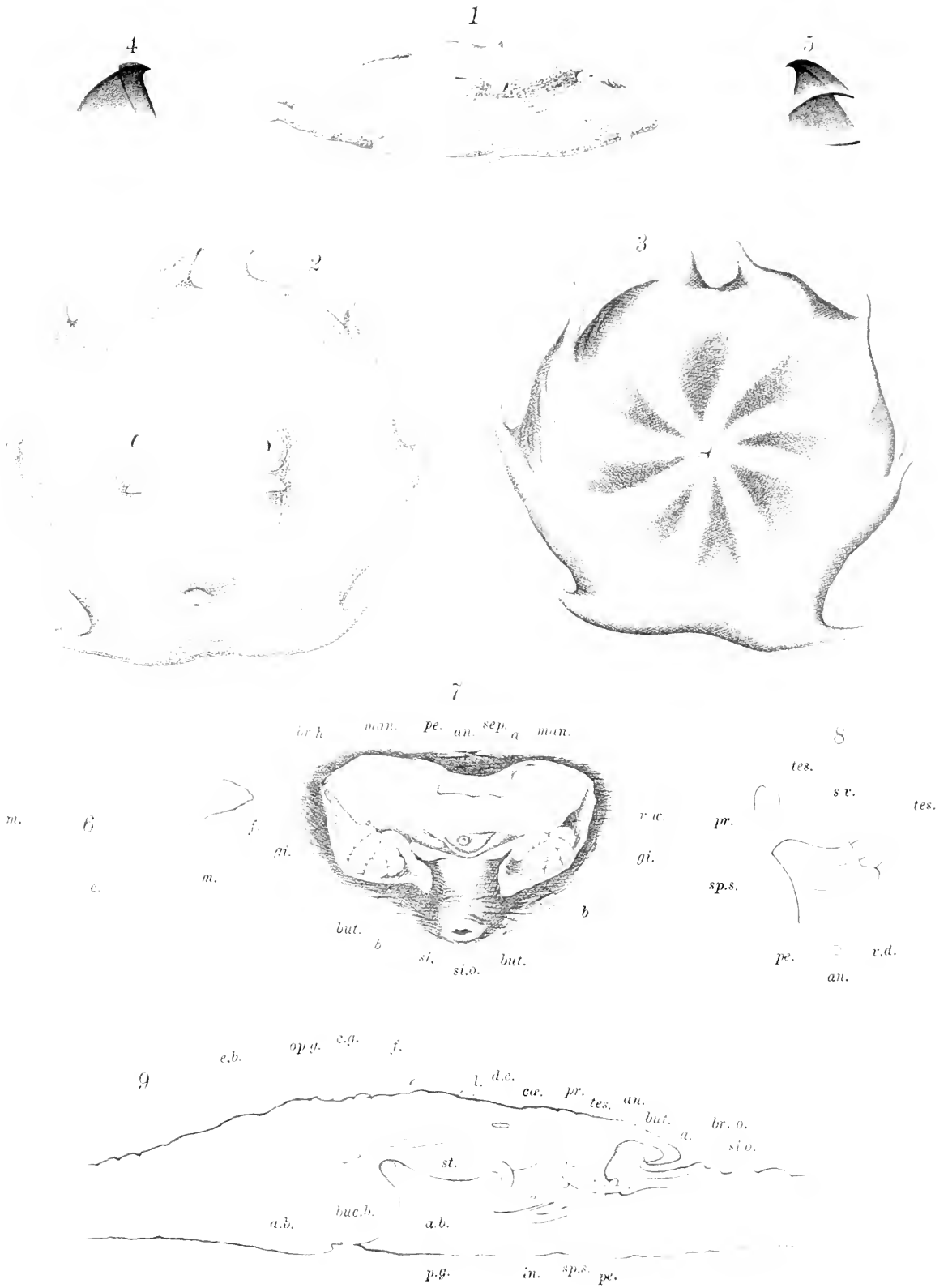






Fig. 1.

cp5  
x110



Fig. 2.

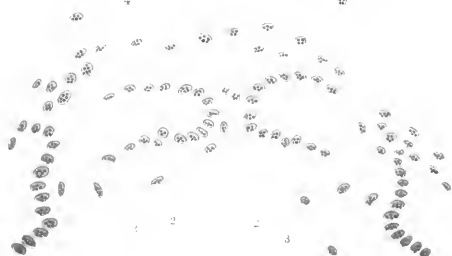


Fig. 3.

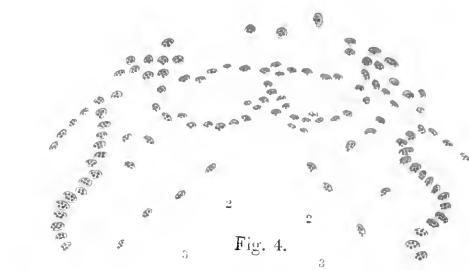


Fig. 4.

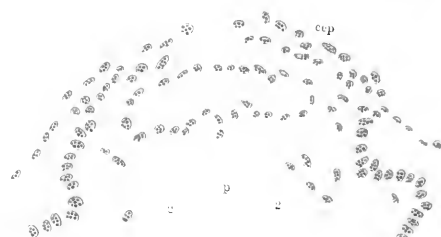


Fig. 5.



Fig. 6.

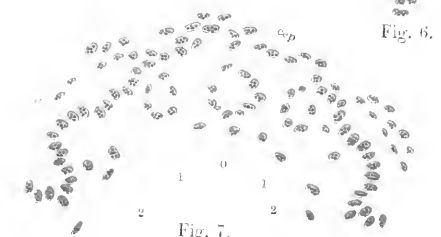


Fig. 7.



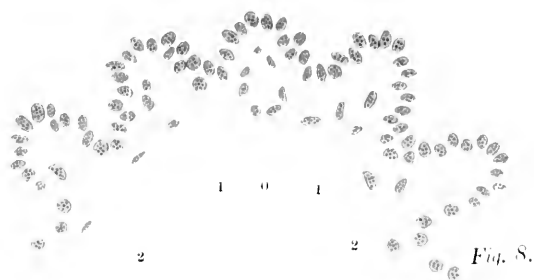


Fig. 8.

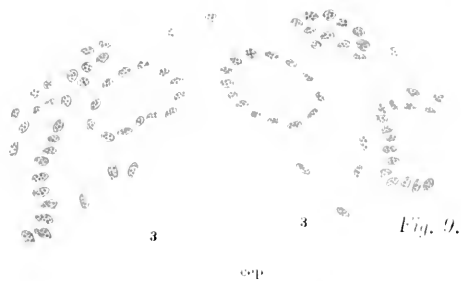


Fig. 9.



Fig. 10.

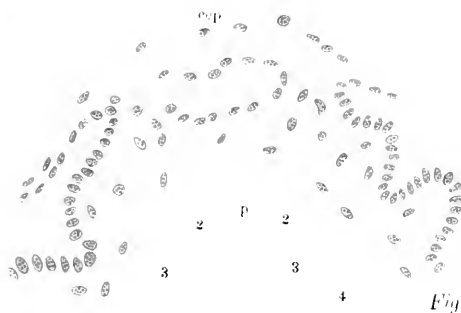


Fig. 11.

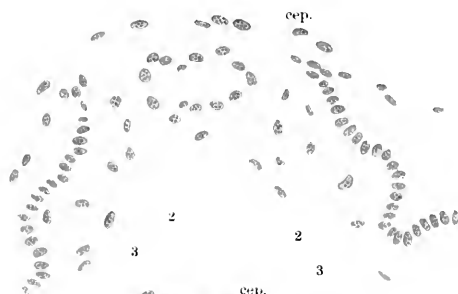


Fig. 12.

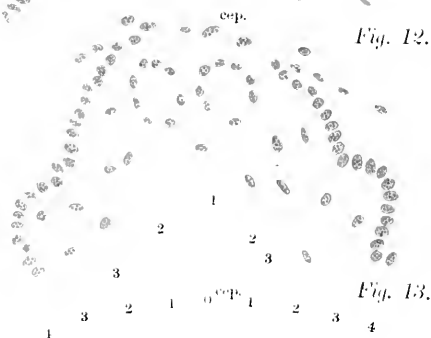


Fig. 13.

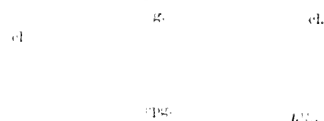


Fig. 14.

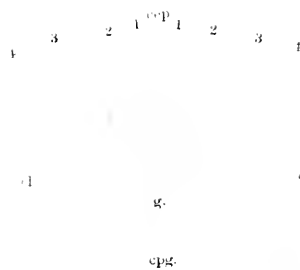
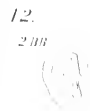
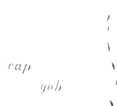


Fig. 15.









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